The Psychology of Efficiency

Under the Editorship of
GARDNER MURPHY

The Psychology of Efficiency

A Discussion of the Hygiene of Mental Work

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PREFACE

Periods of national stress, such as the one we are now passing through, which demand the last ounce of productivity from each of us, call for expert guidance on how to increase our individual efficiency so as to realize the full potentialities that, in more leisurely times, we only half utilize.

There seems to be abundant advice available in book form as far as the physical health side is concerned. Many treatises are to be found on medical care, keeping physically fit, the value of diet and exercise. Nor has mental health been wholly neglected. But the emphasis in this field seems to have been very largely upon the emotional side of mental life. Books on how to avoid worry and overcome fear, how to prevent and remove emotional conflicts and maladjustments, are plentiful, as are treatises on how to avoid friction in dealing with others and how to improve our personalities. All these have an important place in maintaining national morale.

Yet an almost complete dearth of books exists on the subject of mental efficiency; i.e., how the average, normal, well-adjusted person, geared to a daily program of work, can manage to get the most efficient service from his own mental equipment. It would appear that, as a reaction to an earlier period in psychology when there was an overemphasis on the intellectual side of the personality, on thinking rather than feeling, psychologists had gone to extreme lengths in compensating in the opposite direction and had now turned their whole attention to the emotions. The very term "mental hygiene" instantly suggests to our minds the problem of mental diseases and how to avoid them and maintain a nor-

mal emotional life. Why may it not equally well refer to the maintenance of the delicate machinery used in mental work at the peak level of efficiency? Emotions are, in a sense, luxuries with which the majority of persons can ill afford to experiment. But the thinking mechanism is the bread-and-butter equipment of most of us, whether we are students, office workers, executives, or industrial workers performing delicate operations in which the hand must be guided by an alert brain.

It is therefore the purpose of this book to bring together all that has been found out about the hygiene of mental work, the care and maintenance of the thinking machine, and the conditions necessary for its most efficient operation. The reader will soon discover that the expression "mental work" is used in this book in a broad sense; for most work that is not principally a matter of exerting physical strength has its mental aspect.

It will be necessary to spend some time at the outset in discussing the nature of the apparatus involved in thinking, for the competent maintenance man needs a thorough knowledge of the machine which is entrusted to his care. Nor is this analogy of the maintenance mechanic strained when applied to the job of keeping up our equipment for mental work, because the more completely we understand the thought process, the more like an elaborate machine it turns out to be. Experimental evidence is constantly accumulating to show that the entire organism cooperates intimately in the performance of mental work. But it is not enough to be acquainted with the structural characteristics of the bodily organism only. Mental work is a psychophysiological process. This means that it has its subjective aspect which cannot be ignored, for many of the subjective factors which have an important role in promoting efficiency in thinking are so subtle that no organic equivalents have yet been found for

them, even though we fully expect that they will be eventually. These subjective factors themselves are well defined and understood when approached from the conscious side.

For example, when a person is strongly motivated, as a worker would be if he were working for a large bonus or as an inventor is who is burning with zeal to perfect an invention, he is capable of prodigious mental productivity in contrast to his usual output. Yet, as far as can be determined by the most refined methods available, the extra output is not always accompanied by a correspondingly large expenditure of organic energy. When, on the other hand, a person is not adequately motivated or when the work is actually distasteful to him, the cost in energy is quite disproportionate to the meager output. Is this so different from the behavior of other machines? A well-lubricated engine properly adjusted for the load burns less fuel. Similarly, interest, enthusiasm, motive act as the lubricants for the machine that performs our mental tasks.

A book on efficiency should declare its point of view at the outset. Some treatises in the field of applied psychology seem to see the problem of efficiency mainly through the eyes of the employer, that is, as a question of how to extract the greatest output from the worker. It is not strange that the efficiency engineer is sometimes looked upon with disfavor by the worker himself, who feels that he is being sacrificed on the altar of economy. But a better understanding is being created by the efforts of those who see the problem as a two-sided one, in which the individual's interests are at stake as well as those of the employer. Let us say that the point of view of this book is frankly personal, that of the mental worker himself who would like to know how to accomplish the most with the least wear and tear and the greatest long-time satisfaction to himself.

Thanks are due to Professor A. T. Poffenberger for his

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A. G. Bills

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Chapter 1

THE THINKING MACHINE

In this chapter we propose to lay the groundwork for the book by giving a brief but, if possible, clear picture of the mechanisms which actually carry on mental work. It is hoped that the reader will be convinced that the common conception of thought as an insubstantial process carried on in relative independence of bodily activity, or else confined to a small region of the head, is wholly misleading and must be replaced by a picture of total bodily activity calling many organs into play and capable of producing widespread physical fatigue. The term "thinking machine" has been used purposely, because that is exactly what the subject of our discussion is—an elaborate and delicate machine whose capacity to do work depends on the care exercised in its adjustment and maintenance.

The Physical Mechanisms of Thought

We do not need to have a detailed knowledge of neurophysiology in order to understand the basic principles of operation of the thinking machine. Elaborate diagrams of nerve pathways and centers may have value for the specialist but they do little to clarify the main issue, which is how the organism functions as a unitary whole in performing work, particularly mental work.

Let us suppose, for the purpose of obtaining a clear picture, that we have before us a person engaged in a continuous mental task, say a stenographer transcribing a page of dictation on the typewriter. The overall picture is one of an in-

dividual sitting quietly in a chair; but this is deceptive, for closer inspection convinces us that intense activity is taking place even in externally observable bodily mechanisms. To begin with, the worker's *receiving organs,* her eyes especially, are busy. Both head and eyes are focused intently on the page of dictation notes. A mirror held before her eyes would show that they are moving in periodic jerks along the lines, with occasional backward movements, a process which calls for constant readjustment of the muscles controlling her eyeballs. Her head is held rigidly in an attentive attitude and her bodily muscles are tensed. Within each eye, delicate muscles are holding the page in focus, and sensitive photochemical materials are being transformed by the action of the light reflected from the page in such a way as to arouse nervous impulses which travel back along the optic nerves to the visual brain where they excite further nervous activity. It is here that the *integrating process* is directed. The intense activity of the visual brain, in close cooperation with other centers, extracts meaning from the shorthand symbols, sorts them out and translates them into familiar language symbols, and finally converts these words into sequential patterns of motor impulses which are conveyed outward from the motor brain by many separate pathways. The final step in the chain of events is carried out by the *responding organs,* the muscles. Motor impulses reach the muscles of the shoulders, arms, and fingers and move them to press the correct combinations of keys in the correct order, under the guiding control of previously learned habit patterns stored in the brain.

Our picture seems now to be complete; but, in fact, many processes have been overlooked. A large group of these is concerned with adjustments to the work situation as a whole, and it requires no small amount of energy expenditure. For example, if we attached instruments to the worker's chest,

they would show that the whole breathing rhythm has been altered during work so that, instead of following the smooth wave characteristic of the resting state, breathing is suspended for intervals and then catches up in quick gasps. Another adjustment that has to be made is the continual active resistance to distractions which may show itself outwardly only in a worried frown and pursed lips but which internally means the forceful suppression of nerve impulses and of tendencies to action which are excited by these distracting stimuli. The legitimate impulses, related to the performance of the task, have to battle constantly for the right of way against this illicit traffic which clutters the mental highways. For example, persons entering and leaving the room, sudden loud noises from the street, conversation, interruptions, disturbing thoughts, all drain energy into non-productive neural channels. Furthermore, we should not overlook the fact that the working brain acts as a tyrant over the lower nerve centers which have to carry on the vital functions of digestion, circulation, and the like, interfering with their activity by holding them in suspense. It may even suppress these vital functions to a harmful degree if no relief is afforded through occasional rests. Impulses descending by way of the autonomic nerves may slow digestion and retard intestinal action. Last of all, there are the motor impulses which are broadcast to every muscle of the body, setting up tensions in them, even muscles which are only very remotely connected with the task. The student who said that the calves of her legs ached after solving a hard problem in mathematics was not just using a figure of speech. The aching back and shoulders of the typist belong in this class.

A category of bodily effects would be incomplete if it overlooked the fact that most mental work is emotion-provoking, either because of the content worked on or, more often, because of the thwarting effect of making and having to correct

mistakes and the frustration at having to suppress all impulses to stop and do something more pleasurable as the job becomes more and more tedious. It is known that frustration awakens a mild anger reaction which, as the physiologist Cannon (2) [1] has shown, disturbs the endocrine glands, especially the adrenals, and in this way can alter the entire bodily chemistry to a certain degree.

If the objection is raised that these products of mental effort which we have just described are only incidental, we must reply that they nevertheless always occur with it and must therefore be considered in any program of mental work hygiene. If our picture of the bodily effects of mental work seems exaggerated, it is because we habitually overlook the small changes which, if not compensated for, have a cumulative effect on the long-run efficiency of the worker. So we are prepared at this point to list the various organs which actually function and therefore undergo wear and tear in mental work:

The sense organs
The brain and nerves
The muscles
The vital organs
The glands

Before describing at greater length just what fatigue changes can occur in each of these mechanisms, we must pause to make a few general remarks about the organic process of metabolism.

Work Burns Us Up

Every bodily organ which does work must manufacture and expend energy. We speak of the energy exchange, which means the process by which fuel supplied by the blood to the

[1] Bold-face numbers refer to the references at the end of the chapter.

tissues is burned by combining with oxygen in the tissues in order to create energy. The by-products of this combustion process, chief of which is carbon dioxide, are thrown off by way of the blood. The blood stream conveys them to the lungs and excretory organs. Actually only certain tissues—the muscles, nerves, etc.—do the productive work by which we earn our living. The other organs are kept busy supplying them with fuel and flame and carrying away the ashes.

It has long been known that muscles undergo fatigue from work. They consume quantities of fuel and give off quantities of waste, which can easily be measured by the so-called "calorimetric methods." One way is to measure accurately the increased heat radiated from the body, because the heat produced is proportional to the energy generated. Another is to collect the air expired from the lungs by having the person who is being tested wear a mask over his nose and mouth. This air is then tested to determine the amount of carbon dioxide in it, since this is the main waste substance. Or samples of blood from the working tissues can be analyzed, and the amount of waste products, called "metabolites," in excess of normal can be determined. Some of these methods, such as the "respiratory" method in which the expired air is tested, are so sensitive that it is possible to measure the increased effort required to walk on grass rather than on the sidewalk or to sit up rather than lie flat in bed. Of course, repair processes are going on constantly in muscle tissue. But at any given time the rate of consumption of fuel may be so fast that repair cannot keep pace; this condition is what we mean by the term fatigue.

It is only within recent years that the possibility of fatigue of the nerves has been admitted. There were two reasons for this. One was the fact that it was so difficult to demonstrate metabolism in nerve tissue, and the other was that, even after this was conclusively demonstrated, many scientists still de-

nied the possibility that fatigue could occur, because the repair process seemed to be so rapid as to keep pace, even when nerves were worked continuously for hours. But the types of nerve studied were unlike the nerves to be found in the central nervous system, and conclusions based on these studies were correspondingly inadequate. There is still hesitation in admitting nerve fatigue in a metabolic sense, because the amount of fuel consumed is so slight and the by-products are so difficult to measure. The physiologist Benedict (1), for example, remarks somewhat scornfully that several hours of mental work consume no more energy than is contained in a peanut. He arrived at this conclusion, however, by eliminating all muscular effort from his calculated results and including only the amount of energy used by the brain itself, as nearly as he could measure it. This may have some interesting theoretical significance, but it certainly has no practical meaning to us because we have pointed out that the muscular part of mental work is a necessary and legitimate part of it. In fact, as will be brought out later, we could admit everything he says about the small amount of energy consumed by the nervous system and still not alter the case for nerve fatigue.

Thought Is Electrochemical

There is plenty of evidence, which is becoming familiar to everyone, that nerve impulses are partly electrical in character. Perhaps the most striking demonstration is to be found in those experiments with the electrical changes in the brain that have come to be known popularly as "brain waves." Two electrodes are placed against the outside of a person's skull at two widely separated places; from them wires extend to an oscillograph, an instrument which is capable of registering the wave-like changes in the electrical potential

of the brain from moment to moment. Fig. 1 shows the necessary apparatus. There are several types of these brain waves, but the clearest are the so-called "alpha" waves, which have a frequency of about ten per second when the indi-

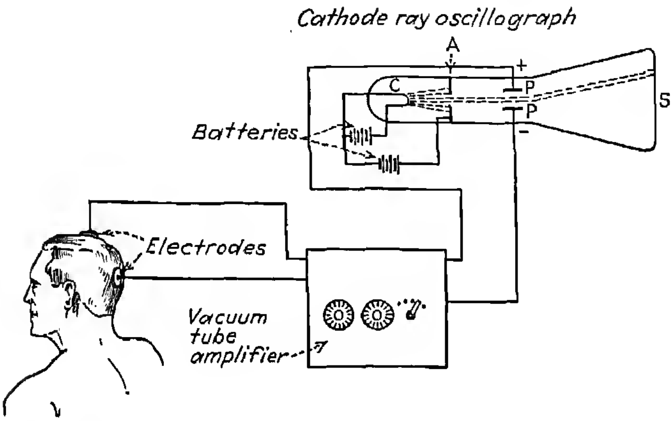

FIG. 1.—Diagram of apparatus and circuit for recording brain waves. (From Crafts, Schneirla, Robinson, and Gilbert, *Recent Experiments in Psychology*, McGraw-Hill, 1938.)

In the cathode ray oscillograph, *C* is the cathode, from which electrons are emitted. A beam of electrons passes through an opening in the anode, *A*, and falls on screen *S*. When changes in the electrical potential of plates $P - P$ occur, the beam of electrons is deflected, and when a succession of changes occurs, as in the case of brain rhythms, curves are traced on the screen. A camera mounted to face this screen will take permanent records of the waves (still or motion picture). Some investigators use a sensitive galvanometer instead of the cathode ray oscillograph, in which case records are made photographically by having the galvanometer mirror reflect a beam of light upon a moving strip of photographic film or paper.

vidual being tested is awake but in a relaxed state (5). Intense mental effort causes the waves to break up into complex patterns and to lose their rhythm. Sleep and sedatives slow them down. Plate 1 shows these varieties of waves. People have characteristic differences in their brain wave patterns which may possibly be related to personality differences. No two

people have identical brain wave patterns; hence it has been suggested that they might be used for purposes of identification. Infants do not show any waves until several months old, and they do not show the characteristic adult wave patterns until after ten years of age. Characteristic brain waves appear in epileptics, and it is even possible to tell in advance the onset of a seizure by the disturbances in the brain waves which occur several seconds ahead of the attack.

A more direct proof of the electrical nature of nerve impulses themselves is obtained by attaching electrodes, wired in circuit with a galvanometer, directly to two neighboring points on a stimulated nerve fiber and noting the deflection of the galvanometer needle at the instant the nerve impulse passes the point where the electrodes are attached. This is known as the "wave of negative change" because it indicates that there was a change in the polarity of the region where the nerve impulse was passing.

It must not be supposed that a nerve current is simply an electrical current; nor is the function of the nerve fiber the same as that of a conducting electric wire. For electricity is known to travel at the speed of light, which is nearly 200,000 miles a second, whereas nerve impulses do not exceed a speed of about 300 feet per second. The reason for this is that the nerve current involves a chemical change in the fiber itself, in addition to the electrical change, and this requires a longer time. A wave of depolarization is set going when the end of the nerve is excited, and an oxidative process sweeps along the nerve in a manner somewhat analogous to a flame creeping along a fuse. Heat is given off, carbon dioxide is produced as a by-product, which means that oxygen has united with combustible materials in the fiber, and a repair process must follow. The nerve will not respond again until a wave of repolarization has traveled along it, but this process

is completed in a small fraction of a second. This short period during which the repolarization is occurring is a resting period for the nerve. It refuses to respond to further stimulation and is said to be refractory, or in a "refractory phase." Muscles, too, have refractory periods which are even more pronounced. Sense organs also undergo similar states so that they can no more receive stimulations continuously than the nerves can conduct them or the muscles respond to them.

A simple but effective way to demonstrate that the energy of the nerves is chemical in origin is to cut off the supply of oxygen and fuel and note the almost immediate stoppage of their activity. This can be done by regulating the volume of the blood supply to the brain, or by altering the oxygen content of the blood by cutting down the quantity of oxygen breathed into the lungs. A person whose brain is not receiving a normal blood supply quickly loses consciousness and all work done by the brain ceases. But what effect does alteration of the oxygen supply have, even when the volume of blood remains the same? We can give an accurate answer to this question because of the large amount of research which has been carried out in the interests of aviation, to determine the effects of high flying (6). It is necessary to know just how high an altitude aviators can reach without losing control of their faculties, because their lungs cannot obtain an adequate amount of oxygen when the pressure of the air surrounding them is too low. The normal oxygen content of air is about 20 per cent. When this is cut down to 13 per cent and below, the mental reactions of the individual being tested begin to show a marked change. He cannot do any mental work like solving problems; his judgment becomes faulty; his memory fails for events which have occurred an instant before; he loses control over his emotions, laughing or crying without reason, or exploding in sudden anger. When the oxygen con-

centration drops as low as 5 or 7 per cent, he quickly becomes unconscious. Yet a few whiffs of pure oxygen will clear his brain quickly. Plate 2 shows a subject being tested.

It is interesting that this method, i.e., cutting down on the oxygen content of the air breathed into the lungs, like all methods of producing brain anemia and thereby lowering the energy of the nervous system, shows its effects first on the more subtle intellectual functions. Judgment and memory and those functions carried on by the highest centers are affected first; the reflexes and other activities of the lower nerve centers are the last to suffer. This may mean that the energy requirements of the higher centers are greater, but it could also mean that a lesser degree of exhaustion in the most sensitive regions can cause a very great interference in the efficiency of their functioning because of the delicacy of the processes involved. It would mean that mere quantitative measures of metabolic rate are inadequate indices of the state of fatigue of these regions. This is the answer to those physiologists, like Benedict, who emphasize the small increase in energy expenditure caused by mental work.

Thinking Is Muscular Work

If the energy expenditure of the nervous system itself were all we had to consider in computing the cost of mental work, it would be a simple matter. However, as our examination of the stenographer in action showed, the muscles play an important part, not simply in the response of pressing the keys but in a number of definite ways which we can now enumerate.

Maintaining a Set.—A number of experimenters have proved that the large skeletal muscles become tense when a person solves simple arithmetical problems "in his head." Delicate instruments are attached to the gross skeletal mus-

cles, for example the biceps muscle of the right arm, and they record the amount of thickening of the muscle when it contracts. A different method is to attach needle electrodes to the muscle and record the "action currents" in it which indicate the changes in contraction that the muscle undergoes. Muscles are always in a slight state of contraction, called "tonus," which prepares them to respond instantly to stimulation; but any increase in the tonus can be detected by the instruments referred to above. In sleep the tonus is low, and even when we are awake but in a generally relaxed state it is slight; but when we undertake any task requiring close attention, the muscles show increased tension. We can truly say that at-*tention* is in large part bodily *tension.* Of course, the metabolic cost of keeping a muscle in this tense state is not as great as that of lifting weights or doing heavy muscular work, but it cannot be ignored and it constitutes an important element in mental fatigue. The psychological term for this type of response, in which the muscles become tense in preparation for a task requiring close attention, is "set." Set is explained as the organism's way of putting itself in a state of alertness or vigilance which spurs the brain on to greater activity. Up to a certain point any increase in this tension has been proved to facilitate the speed and accuracy of thinking while it is going on; but beyond a certain point the effect becomes detrimental, as when a person about to speak before an audience becomes so tense that his ability to think clearly on his feet is retarded.

Incipient Responding.—Psychologists have long suspected that thoughts or ideas are activities which are not confined to the brain but involve adjustments of the smaller muscles as well. In other words, thoughts have been considered the beginnings of responses which are not allowed to come to complete bodily expression, but which are nevertheless stages in the series of bodily adjustments that lead up to and set the

stage for the final overt act. For example, this theory would assume that if we are insulted by someone and have thoughts of taking physical revenge on him, our muscles, particularly those in the arm and fist, will be tensed, even though the action never occurs. Experimental support for this belief has recently been provided by Jacobson (3). He fastened electrodes to various muscles of his subject, who lay relaxed upon a couch. When he asked his subject to imagine that he was doing various things such as shaking a furnace, he found that the muscles which would normally be used in actually performing the acts showed "action currents," i.e., electrical changes, indicating that slight contractions were occurring in them at the instant that the thought occurred. Photographic records of these action currents are shown in Plate 3.

The eyeball muscles seem to be particularly active in thinking. It has been suggested that the vocal muscles must also have a large share because we do so much of our thinking in verbal or language terms. This has been called "subvocal speech" because it involves contractions of the muscles of the speech organs and yet no sound occurs. While it is true that experiments do indicate plenty of movement of the vocal, tongue, and lip muscles, particularly in distracting surroundings as when a person is trying to add a column of figures while people are talking loudly in the room, it has not been shown that these muscles actually form word-like patterns. Do deaf mutes show movements or contractions of their fingers when they think? Max (7) reports finding that action currents actually occur in the fingers of deaf mutes when they are dreaming or are imagining actions or even thinking abstractly while awake.

The objection has been raised that none of these findings prove that the muscle contractions which occur are actually necessary to the thinking. Perhaps thinking could take place without them under ideal conditions of quiet and freedom

from fatigue. But from the practical point of view, if they do occur with nearly all thinking, their metabolic cost is one of the elements to be reckoned with in computing the energy cost of mental work.

The Hygiene of Mental Work

If we have succeeded in establishing our case and have demonstrated convincingly that the thinking machine really involves the whole organism, that it manufactures and uses up energy, that it undergoes fatigue in a physical sense and therefore recovers through rest, we are now prepared to outline a program for the hygiene of mental work. A brief survey of the main topics to be considered in such a program will be given now and expanded later in the remaining chapters of the book.

Controlling the Energy Level.—One of the striking facts about human behavior which seems to set it apart from the behavior of machines is the fact that an identical stimulus rarely calls out the same energy of response on different occasions. We can be reasonably sure how much energy an automobile will show at any given time in response to the pressure of our foot on the accelerator. But human beings show all degrees of reactive energy, from that of the sleeping person who fails to respond when his name is shouted, to that of the runner who is poised for a hundred-yard dash and whose whole body explodes with energy at the drop of the starter's handkerchief. For ordinary workaday purposes neither of these extremes is desirable. The first is inadequate for efficient work and the second would soon result in a nervous collapse if sustained for any long period of time. The problem is to study the factors which control the level of responsiveness so that a steady flow of energy, which is just adequate to the task at hand and which avoids waste of valu-

able nervous reserves, can be assured at all times. This subject will be taken up in Chapter II.

Fatigue, Rest, and Recovery.—It is one thing to know that fatigue from mental work is a physical actuality, but it is another thing to be able to measure it, follow the course of its development, decide when the thinking machine requires rest, and know how much recovery can be expected from a given amount of rest. We are now prepared to answer these questions with some degree of confidence because psychologists have performed research of a quantitative nature which makes this possible. The course of the development of fatigue during continuous mental work of a routine type has been mapped from minute to minute. The problem has been studied from at least four different angles, i.e., changes in output, changes in the worker's own subjective feelings, changes in his physiological condition, and changes in behavior symptoms indicating an increasing general nervousness. The problem of rest has been studied with similar care. We know how long and how frequent rests should be, what activities should be engaged in during them, how much rest is afforded by a change of task rather than doing nothing, and how the development of excessive amounts of fatigue can be avoided. As the word is used in this book, "fatigue" need not mean complete breakdown of capacity. In fact, any reduction in the efficiency of the thinking machine, however slight or temporary, can properly be called fatigue. Many people fail to recognize mental fatigue when it is actually present in themselves because they tend to expect the same feelings which accompany physical exhaustion. Mental fatigue does not feel like physical exhaustion except when it is extreme, and even then it may take the form of an inability to quiet down and relax rather than producing the feelings of lassitude that are so characteristic of physical fatigue. The best workable definition of fatigue from mental

work which can be given is this: It consists in a decrement in the ability to accomplish work, in subjective feelings, and in nervous control, which is removed by a given amount of rest. These problems will be discussed in Chapters III to VII inclusive.

Sleep, Normal and Abnormal.—Sleep is usually no problem to physical workers. Unless overtired, they experience a pleasant drugged feeling which promotes sound rest. But the mental worker is likely to lie awake while his brain grinds away endlessly on the very tasks from which he is trying to recuperate. Intelligent sleep control is therefore an important topic in the psychology of efficiency. A large number of theories have been proposed to explain scientifically why we sleep. Some have contended that it is because we are drugged with fatigue products; others appeal to a sleep instinct or a brain center; still others suggest that the nerve centers disconnect themselves, causing a mental blackout, just as a light is switched off by breaking the electric circuit. And there is the amusing controversy that was once waged as to whether we sleep because we lie down or lie down because we are sleepy. But one fact stands out clearly; this is that the regular rhythm of diurnal sleep, as we know it, is a learned habit acquired from past experience and that, like other personal habits, it may not have been properly learned in the first place and hence may have to be taught all over again. We know something of the normal sleep requirements of the average person, and also some of the physical and psychological consequences of prolonged periods of insomnia. Chapter VIII is concerned with these and other problems of sleep.

The Work Setting.—Another of the striking differences between men and machines is that machines are practically independent of their surroundings. They work as well on gloomy as on sunny days; they are not disturbed because the boss has a grouch; the ungodly clatter of other machines and

human voices does not distract them; they do not suffer from the blue Monday slump or the late afternoon lag; they are not depressed by the drabness of their surroundings. How different it is with the human thinking machine! We are to a great extent at the mercy of our environment in these matters. But a knowledge of the factors involved and the ways in which they affect us can put us in a position to deal with them more effectively. It may mean changing the environment; more often it means changing ourselves in such a way as to adjust to the work setting; but in either case efficiency is benefited. Some years ago Mayo (8) demonstrated that the gloomy daydreams indulged in by the workers in a certain industry who were not well adjusted to their work setting could cause great inroads in their productivity. By making certain adjustments in these relationships he was able to increase their output and reduce the rate of turnover to a surprising degree. Chapters IX and XIII cover all the factors whose effects are well known.

The Dynamics of Efficiency.—We must distinguish clearly between the mechanics of behavior on the one hand, and the dynamics on the other. The former has to do with the capacity to perform, the latter with the desire or willingness to do so. One of the clearest memories of the author's childhood is of looking at a photograph in an animal book which showed a man sitting on the back of a giant turtle and having a ride. He was holding a long pole with a piece of meat on the end of it out in front of the turtle's head just far enough to be out of its reach. The animal was patiently waddling along trying to catch up with the tasty morsel, but he could never quite reach it. In the meantime the man was having a fine ride. The significant point is that, by appealing to a reliable motive of the turtle, i.e., its hunger, the man was able to obtain a steady output of energy from it. If he had not appealed to the motive—or "drive," as it is often called—but

had tried to force the animal into action by externally applied pressure, it would without doubt have remained motionless.

Fig. 2.

(Drawn from actual photograph in *Living Animals of the World.*)

Motives are the dynamic factors in work, the keys for the release of energy in human and animal behavior. Work must be properly motivated to be efficient. Motives are internal factors whose presence in all people we can count on to call out their efforts. Certain motives are stronger in some persons than in others, but in the main they run true to form. These internal motives must be appealed to or excited by external factors, called "incentives," which have the capacity to satisfy the motives and thereby stimulate a person to put forth effort in order to attain them. What are the most reliable motives,

and what incentives can be counted on to call them forth most consistently? Is it possible to over-motivate a person so that his efficiency is adversely affected? How can we motivate outselves more effectively when we find our energy lagging or our enthusiasm for a task failing to carry through on the long pull? What can be done about the situations in which motives conflict with one another and create emotional strain that saps efficiency? These are some of the questions which Chapters X, XI, and XII attempt to answer.

Gaining Efficiency Through Learning.—Most of the acts of skill that enter into a day's work are performed with far less than half the efficiency of which we are capable, as is demonstrated by the feats of experts. These experts are not superior persons but average individuals like ourselves, but they have given attention to practicing certain skills until they have mastered them. Many of us are retarded from attempting further improvement through learning, because of false notions about the amount of time, effort, and ability required. Some economical methods for perfecting skills, acquiring knowledge, and removing undesirable habits are discussed in Chapter XIV.

Age Changes and Efficiency.—How much does advancing age lower our efficiency? In what particular ways does it affect it? Are all functions equally affected, or may some abilities actually improve? Can the effects of advancing age be counteracted? Every one of the factors whose influence we have been discussing undergoes changes with age. Motives change, attitudes are transformed, abilities are affected in varying degrees, some of them deteriorating, some holding their own or even improving. It is possible to face advancing years with little fear of the loss of overall efficiency if we reappraise ourselves from time to time and rearrange the pattern of our lives in accordance with the shift in our capacities.

Some concrete principles to this end are presented in Chapter XV.

Organization and Planning.—There are more reasons for an accurate self-appraisal than the necessity of adjusting to age changes. It should precede the selection of a vocation, the choosing of a particular job, and the planning of one's whole career. Self-appraisal should embrace a much more comprehensive program than merely measuring one's abilities and securing the proper vocational training. The whole personality needs to be taken into consideration. There are emotional needs that must be satisfied if we are to be contented in our work. There are levels of aspiration that must be readjusted on a frank basis of reality as we reach maturity. They are sometimes hangovers from a starry-eyed youth and have no place in mature plans. There are steps to be taken in the direction of both the systematic correction of weaknesses and self-improvement. Finally, there is the vital problem of budgeting time for work and leisure hours. Often this is the deciding factor between success and failure from school days to retirement at the end of the working life. Chapters XVI and XVII give a basis for vocational planning and life planning.

Effective Thinking.—The final chapter of the book is concerned with an essential aspect of efficiency: how to improve the effectiveness of our thinking in the solution of everyday problems. The process of thinking is analyzed into its essential elements, and ways are suggested for rendering more effective each of the steps in the process. Some of the commonest pitfalls that occur in reasoning are discussed. Finally, a comparative list is presented of the attitudes of mind that enter into adequate and inadequate thinking. Much of the energy expended in thinking can be saved by making sure that none is wasted in lost motions.

It has been necessary in this chapter to introduce a number of terms which are more or less technical. The reader who desires a definition of them is referred to the Glossary at the end of the book.

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Chapter II

REGULATING THE THINKING MACHINE

THE general problem of this chapter is to account for the changes that occur from moment to moment in the energy level of the brain, causing variations in the output of the thinking machine. If we know what factors cause these rises and falls in energy level, we may be in a position to control them so as to maintain the level at an optimum point for efficient performance at all times. Since these factors do not all operate in the same direction but frequently work against one another, some acting as depressants to lower the excitation level and others acting as stimulants to raise it, it is necessary to use a two-way concept for the processes involved. The technical terms are "facilitation" and "inhibition."

FACILITATION

Some years ago, in the psychology laboratory of the University of Chicago, Miller (8) performed an interesting and significant experiment. She first taught her subjects to relax completely, in accordance with the method devised by Jacobson (6), as they sat in an easy chair in the laboratory. This method consists in having the subject progressively relax each muscle group in the body. It requires a long period of training. When they had perfected this, she experimented with them under two opposite conditions: in one they sat in the chair in a normally alert attitude, and in the other they relaxed completely. In both conditions she stimulated them by applying an electrode to their arm and shocking them with a strong electric current. The amount of involuntary

jerk of the arm was recorded by appropriate instruments, and they were asked how much pain they felt. The interesting finding was that, whereas in the normal condition of alertness her subjects gave a vigorous jerk of the arm and reported a strong sensation of pain, in the relaxed condition they not only showed little or no arm jerk but reported a greatly reduced sensation or none at all from the shock. Other psychologists, notably Freeman (3), have completed the picture by introducing a third condition in which the subject was told to squeeze a dynamometer during the period of stimulation, or to maintain an upright posture after the back of his chair had been removed so that no support was given. In both these new conditions, a large increase in muscular tension was produced. The idea was to find out whether additional muscular tension above the normal would increase the reaction to the electric shock. As it turned out, the subject was made so alert by the extra tension that he tended to respond before the stimulus was given, and his sensations were so intensified that he could not distinguish between a weaker and a stronger shock.

What do these results tell about the working of our thinking machine? They show clearly that it does not react with the same readiness at all times, but that the quickness of the response and the intensity of the conscious experience accompanying it depend on the state of the organism at the moment. If the body muscles are tense, the brain reacts quickly and intensely; if they are relaxed, it may react much more weakly or not at all. This indicates that, without some sort of constant reinforcement of its excitation level, the brain can function only at a low efficiency, if at all. The tensed muscles send a constant flow of nerve impulses back over the "proprioceptive" nerves to the brain and keep it in a state of alertness, or "vigilance" as it has been aptly called. Experiments by the author indicate that mental work is improved

in both speed and accuracy when extra tension is induced in the body musculature. But there is apparently an upper limit beyond which tension becomes a depressant rather than a stimulant. For example, Stauffacher (10) demonstrated that when his subjects increased the tension in their arm muscles they increased their speed in the memorizing of material; but both he and Courts (1) found that when the tension exceeded an optimum amount the learning was interfered with. Freeman (3) showed that the amount of tension which would prove most beneficial depended on the type of task which was being done. The explanation of these factors will be given later in the chapter.

The examples given above are concerned with only one type of facilitating mechanism, muscular tension. We can conveniently class this with the group of "internal" facilitators in opposition to another large class, the "external" facilitators. It may help to keep the picture clear if we discuss these two groups separately.

External Facilitators.—One of the studies of the brain waves of animals showed that if all external stimuli were cut off from the sense organs of a cat whose brain waves were being recorded, the waves had a steady rhythm, meaning that the brain was in a quiescent state. But when a light beam was directed upon the cat's eye, a complex pattern of agitated waves appeared. We all realize that one of the best ways to achieve mental relaxation is to sit in a darkened room in perfect quiet, with clothing loosened and all external stimuli cut off. This is because cutting off the sources of mental excitation allows the brain to fall back upon its own intrinsic energy level, which is relatively low. Under ordinary conditions, however, we are constantly kept at a higher excitation level by the host of external stimulations impinging on our sense organs. Most of them are not responded to by any particular act on our part, but they do

change our state of readiness and so affect the responses that we make to our task.

This discovery has a number of practical applications. If a person is working steadily at a very monotonous task, the operation soon becomes so automatic that it does not demand enough attention on his part to keep his brain alert. He is likely to lapse into a semi-waking state of abstraction, or "woolgathering" as it is commonly called. This is a sign that the excitation level of his nervous system is slowly sinking to a point where it will no longer be efficient. At this point output slows up and mistakes occur. In industrial workers it means an increase in accidents and in spoiled materials; in mental workers it means wasted time. We have all had the experience of sitting with a book before our eyes, carrying on the act of reading automatically, yet later not knowing a word of what we have read. We find it necessary to reread the same passage several times. One remedy for this is to deliberately arrange a source of external or internal stimulation that will raise the excitation level of the brain.

This principle has already been seized upon by industrial psychologists for speeding up war-time production. Thus the playing of music during work hours in the industrial plants of England has been found to increase output as much as 13 per cent. American industry is using similar methods. In fact, experiments in this direction were made here as early as 1922. One of these, quoted by Diserens (2), was carried out in the Minneapolis post office when a phonograph was played during sorting hours; as a result, errors in sorting were reduced over 13 per cent. About the same time, Gatewood (4) reported that architectural draftsmen found music beneficial when played during their working hours. Forty-nine of a group of fifty-six were definitely helped, while only six were distracted by it. Some investigators have attributed the results in part to rhythm. They argue that the music sets a

rhythm for the work. But this applies more to muscular than to mental operations. Others have suggested that music stimulates them through its appeal to their emotions. If this is true, then it is a case of an external facilitator producing its stimulating effect on the brain indirectly by arousing an internal facilitator.

The line between the external stimuli which are energizers in the above sense, and those which act as distractors, is finely drawn. It is partly a matter of intensity. Any facilitator can become a distractor if it is too strong, or if it commands so much attention that it no longer stays in the background of consciousness but leaps into the foreground. More will be said on this subject in Chapter IX in connection with the discussion of attention and distraction.

Visual stimuli play as important a part as auditory ones in keeping the brain alert. But usually the eyes are busy on the task and any additional stimuli would prove distracting. It is significant, though, that Pressey (9) found a direct relation between the general brightness of the room in which such mental tasks as multiplication and serial reactions were being performed, and the quality and quantity of output. And Johnson (7) found that optimal visual work conditions require that the background be as well or better illuminated than the foreground.

The presence of other people, whether they are working with one or are merely in the same room, is an effective excitant to many persons. Voices over the radio sometimes have a similar effect, but too often they prove a distraction because of the irrelevant trains of thought which they set in motion.

Internal Facilitators.—We have seen that some degree of tension in the body muscles helps to maintain the vigilance of the brain. This can easily be promoted by the body posture during work. Naturally it is more fatiguing to sit erect than to slump down and relax, but it is also more stimulating to

thought processes. Over reasonably long periods of work, the benefit outweighs the loss. We must take into consideration personality differences. Some persons are so stimulated in other ways that the added factor of tensed body muscles is superfluous. Others are so habitually relaxed that they work far below their capacity. The latter are the ones who benefit most from an erect posture. An alert bodily attitude means an alert mental attitude.

Certain physical agents act as internal facilitators. Those that speed up metabolism slightly, without causing a later depressant effect on the heart, are the best. Coffee and other drinks containing caffeine are of this type. Tobacco and alcohol are not, because any temporary positive boost they give is outweighed by the later slump. It must be admitted, though, that habitual smokers become so dependent on the soothing depressant effect of the drug and the ritual they go through in smoking that they would be inefficient without it. Probably persons with a great deal of physical or nervous energy, who find that sitting still to do mental work puts too great a curb on their impulses to action, actually feel more contented when their metabolism is being depressed by tobacco.

Motives are powerful facilitators. But the common everyday goals to which human beings respond are not steady enough to be depended upon alone. They energize us when they are in the forefront of our thought and when they have been freshly appealed to; but in time they recede from attention and, unless they are replaced by habits or attitudes which operate automatically, they lose their effectiveness. A glimpse into the private lives of famous people is illuminating on this point. It is said that William James, the father of American psychology, never would have finished his famous two-volume textbook, which took eleven years to write, if the need for ready cash had not compelled him to send the pub-

lishers a chapter of manuscript now and then so as to induce them to advance him loans against his future royalties. When a goal is fresh before our conscious thought because it has been newly excited by something someone has said or something we have experienced, we are energized by it temporarily to a high level of efficiency, but this soon wears off. However, it may be replaced by a permanent work "set." This is the psychological term for those persistent attitudes which may become habitual and operate without any particular effort or, for that matter, without any particular attention on our part of which we are aware. These sets, which are the subconscious neuromuscular traces of half-forgotten goals, are the guiding and directing forces in all sustained mental work. They form a fourth group of internal facilitators.

To these we must add a fifth group, the emotions. They are unique because their stimulating effect is produced in several ways. First, they directly raise the excitation level of the brain by the overflow to it of energy from the lower center from which they originate. When aroused by emotional stimuli, this lower center, called the thalamus, is capable of increasing the energy level of the nervous system tremendously. Secondly, they add indirectly to this effect by exciting the body metabolism, heart rate, breathing, glandular secretions, and the like. In this respect they act like a powerful drug such as strychnine. Finally, they excite the body muscles to increased tension and, as we know, this further raises the energy level of the brain. The sum total of all this may be just adequate for optimum efficiency, or it may be so excessive as to interfere seriously with efficiency. It depends on the nature of the job with which one is confronted. A person who must deliver an inspiring speech has to be emotionally aroused, "all hopped up," in order to impart enthusiasm to his listeners. This is true of a lawyer pleading a case before a jury. But a debater, or a lawyer arguing before an impartial

judge, must be calm and have his emotions under complete control if he is to remain clear-headed. We have mentioned the fact that music has a beneficial effect when played during work hours, partly because it imparts a pleasurable emotional excitement to the workers. In this case, the degree of emotional excitement seems to be just optimal. The general conclusion can be drawn that the wise individual must so manage the emotional stimulations which he receives as to obtain the optimal degree of facilitation from them. Concrete suggestions as to ways of accomplishing this are reserved for Chapter XI.

To summarize briefly, we have indicated a number of external and internal facilitators whose proper control can insure an energy level of the brain which is just adequate to efficient mental work. These are

- External
  - Sensory stimuli from the background
  - Social stimuli
- Internal
  - General muscular tonicity
  - Physical agents
  - Motives
  - Sets or attitudes
  - Emotions

The secret of efficiency is to make allies of these factors; if we leave it to chance to combine them, they may prove to be detrimental to performance.

Inhibition

We have seen that, in the absence of the various facilitative factors, the excitation level of the brain may fall to a point that is too low for the brain to function adequately in reacting to stimuli or in doing work. But, in addition, there are

active processes which exert a depressing effect either in a general way on all mental operations, or in a specific way on particular responses. These are the inhibitors, and they also are both external and internal.

External Inhibitors.—Any stimulus, anything happening around us when we are already engaged in an activity will affect that activity in some manner. How it affects it depends on whether the new stimulus calls out responses which can fit into the present activity or whether it calls out antagonistic responses or responses that are extra to the main activity and require a drain on the total energy available at the time. Shouts of applause during a speech or play never inhibit a speaker or actor, but the coughing and squirming of the audience have been known to completely disrupt his performance. Hence the question at issue is, under what conditions is one or the other of these effects likely to result? It should be kept in mind that, in a very complex activity, both positive and negative effects might occur at the same time.

Intensity.—Any facilitator can become an inhibitor if it is too strong. This is true of all those background stimuli like music and illumination just discussed. This fact is sometimes accounted for in terms of the principle of "dominance." The stronger stimuli excite nervous pathways which become dominant over the ones being used for the work at hand. The result is that these irrelevant pathways draw energy from the legitimate responses and the work suffers. The low rumble of downtown traffic goes unnoticed, but the sudden screech of rubber on pavement, when some driver jams on his brakes, can temporarily disrupt work in all the surrounding office buildings.

Time Relations.—Irrelevant stimuli that facilitate the performance of work when the time relations are right may seriously interfere with it if these relations are not right. Studies carried on by industrial psychologists in Germany a

decade or so ago showed that when rhythmic stimuli were introduced into a work situation for the sake of increasing efficiency but did not fit the natural work rhythms, they increased the weariness of the workers.

Meaningfulness.—Stimuli that arouse antagonistic trains of thought need to be avoided. Human voices in conversation, even over the radio, can do this. They are much more inhibitive than mechanical stimuli because they are so much more meaningful. Probably, in the illustrations above—e.g., the screech of brakes suddenly applied—it is the meaning of the sound as much as its loudness that causes the distractive effect on the office workers.

Internal Inhibitors.—Just as persistent sets or attitudes which can exert a reinforcing influence on our work are carried over from previous conscious goals, so also must we expect to find inhibitive sets which block positive action or weaken it. Sit-down strikes and slow-down strikes of the thinking machine can be engineered by these inhibitive attitudes, without any intention or awareness on the individual's part. Often these inhibitive sets result from suggestions the individual has given himself. The suggestion of failure can put a damper on one's performance and eventually destroy his efficiency even though he is perfectly capable of success. Professor Hull, who experimented a great deal with both hypnotic and waking suggestion, tried the following "waking" suggestion on his classes: He would ask them to observe him and do just as he did; then he would lock his hands together by interlacing the fingers of the right and left hands and pressing hard. When they had done likewise, he would tell them to try to pull their hands apart but that they would find this impossible, no matter how hard they tried. After a strenuous effort, several of them would give up trying. Others would be able to separate their hands, but only with difficulty. They were simply reacting to an inhibitive

set which Hull had established in their nervous systems by suggestion. If a person is convinced that he cannot do something, this acts effectively to block any attempts which he makes to do it, no matter how sincere.

Emotional Inhibition.—We have already discussed the fact that when emotions are aroused they add greatly to the excitation level of the brain. If, at the same time, one is engaged in some very strenuous action which requires mobilizing energy, such as running a race or acting a dramatic part on the stage or even delivering a speech, the extra nervous energy is beneficial. But for quiet, routine work it is more likely to be disruptive. There is a type of personality called "cyclothymic"; this merely means the tendency to have decided emotional ups and downs, swings from elation to gloom. Such people are constitutionally unfit for routine mental work. But the average person, whose emotional swings are not constitutional, can usually avoid emotion-provoking situations or, if they arise in the work situation itself, sidetrack them or deliberately set about to remove the factors responsible.

One of the characteristics of emotional inhibitions which has been clearly understood and named by students of abnormal psychology is "spread of inhibition." This refers to the fact that an emotional inhibition which was originally aroused by some very particular experience has a tendency to spread to the whole personality and exert a depressing effect on all its activities, even those having no connection with the experience in question. When a student in college complains of inability to concentrate, inability to remember things, it often indicates the presence of an emotional conflict which may be quite particular, even trivial, but which has spread to his other activities and is exerting an inhibitive effect on everything he does. There has been a "transference of affect," to borrow another term from abnormal psychology. This may render all mental work distasteful. Efficiency

in our daily routine demands that such sources of spreading psychic paralysis be tracked down and eliminated.

An important type of inhibition which should be added to our list, i.e., the gradual decrement in performance of a continuous task that is highly monotonous, will be discussed in the next chapter. This has been called the "inhibitory effect of work upon itself." A more common term for it is mental fatigue, but it is only one of the kinds of fatigue with which we shall be concerned.

To summarize, we have identified a number of different sources of inhibition in work. They are sometimes external and sometimes internal in origin, and they can be grouped under the following heads:

External stimuli of certain types and degrees
Inhibitive sets and attitudes
Emotional inhibitions
Highly repetitive work

The purpose of this chapter has been to identify and explain the factors that are responsible for varying the energy level of the brain, rather than to suggest specific methods of procedure. That has been reserved for later chapters. Nevertheless, a few general suggestions are in order here.

Reduction of Hypertension

When a person finds that his efficiency is being interfered with by either a temporary or a permanent state of hypertension, no matter whether this is of emotional origin or springs from his temperamental makeup, a remedy is available in voluntary progressive relaxation. A technique for accomplishing this is described by Jacobson (5). Naturally, the method has to be applied in leisure hours, but the effects should carry over into periods of work. Probably the chief source of harm, in the case of the hypertense individual, is

not the development of excessive tension during work, though this is important, but the inability to throw it off after work hours. Such a person can really be said to work twenty-four hours a day, as far as the expenditure of energy by his muscles and nerves is concerned. He is likely to suffer from insomnia because the tense attitudes persist after he retires. It is here that the relaxation methods become particularly valuable, as is brought out in the discussion of insomnia in Chapter VIII.

Balancing the Energy Level of the Thinking Machine

The secret of the efficient operation of the thinking machine is to maintain the excitation level of the brain at an optimum point so that its own intrinsic energy is adequately reinforced for the extra demand made upon it by mental work. To use the analogy of the automobile engine, we must avoid either flooding or starving the combustion chamber. This means regulating the external surroundings, maintaining the optimal degree of tension in the body muscles, seeing that we are adequately motivated for the job, and controlling the amount of emotional stimulation that we receive. Every individual needs to study himself to find out what his own requirements are. He may find that he is of the understimulated type, working far below his capacity. Such a person should utilize the sources of extra stimulation outlined in this chapter. Or he may find that he is already working at or near capacity, in which case any additional excitation becomes disruptive. Again, he may discover that his energy flow is unsteady, consisting of spurts and slumps. This calls for the establishment of habit patterns or sets which will regulate the work tempo. Whatever the individual peculiarities, they can be corrected by a patient application of the

psychological principles outlined in this and subsequent chapters.

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Chapter III

MENTAL WORK AND MENTAL FATIGUE

It is one thing to know that thinking is a bodily activity carried on by the whole organism, which uses up energy and develops fatigue, but it is quite another to be able to measure the amount of fatigue developed accurately enough to answer all the questions we need to ask. For example, in order to take proper care of the thinking machine and obtain the most efficient use of it, we must know how rapidly it fatigues from given amounts and kinds of work. We must also know whether there is a danger point beyond which the cost of operation is excessively great in terms of long-time efficiency and personal welfare, and what the relation is between given amounts of fatigue and the quantity and quality of mental work accomplished. We must be informed as to the methods which can be used to cut down excessive fatigue. All this implies accurate measuring methods. But it is necessary to know clearly what we are measuring and whether it is too complex and many-sided to be measured by a single method.

Four Aspects of Mental Fatigue

To return to the picture of the stenographer working at her typewriter, there are at least four ways in which we could estimate increases in her state of fatigue from time to time. One method would be to measure the amount which she accomplishes during equal successive periods of time. This of course assumes that she continues to try just as hard and that her output is limited only by her capacity. This could safely be assumed if she were working for a bonus or in response to some other constant incentive; otherwise, we might con-

fuse lack of interest with fatigue. Another method would be to measure her organic fatigue by taking a record of changes in her metabolic rate; for this there are several special techniques to be discussed presently. A third method would be to observe and record any outward signs of nervous tension, such as excessive tonus of the muscles, fidgeting, lessened emotional control, or lassitude of manner. This last would admittedly be a very inexact way of estimating fatigue, but it could be used to supplement the others. A fourth method would be to ask the subject herself for periodic reports on her feelings. These would have to be expressed in some quantitative way so that they could be given scale values. All sorts of feelings would have to be considered, including particular bodily sensations like headache, backache, loss of zest for work, inability to concentrate, and the like. These four methods are known respectively as:

The objective method
The organic method
The by-products method
The subjective method

The objective method is discussed immediately below; the organic, on pages 72–76; the by-products, on pages 76–78; the subjective, on pages 84–94.

Finally, the results of all these methods would have to be combined. If they all varied together in a fairly consistent way, we could infer that all of them were getting at the same fundamental thing. But if they showed a tendency to vary independently, we would have to assume that fatigue is such a complex thing that no one measuring method is sufficient to give a true picture.

The Objective Method

The objective method proceeds on the assumption that fatigue is defined as a diminished capacity for work, as

shown by a decrement in output. Historically, this diminished capacity was supposed to be general and to affect any type of response which the fatigued person made, not just the particular performance in which it developed. For example, it was supposed that one could judge how much a person had fatigued from two hours of work on multiplication problems by testing the strength with which he gripped a dynamometer or the speed with which he made a simple voluntary reaction like pressing a key in response to a light flashing on. This led to two quite different objective procedures for measuring fatigue: one, the interpolated task method, and the other, the continuous work method. In the former, some test like the dynamometer or the reaction time was given the worker at stated intervals during continuous work. If the strength of grip grew weaker or the reaction time slower in successive test periods, it was assumed that this was a measure of the amount of fatigue developing. But there was a false assumption behind this method, i.e., that fatigue from a particular mental operation is general and affects all responses equally. The point is that a person working continuously at multiplication might grow very tired of multiplying, so tired that he could not do another problem, but this would not necessarily affect his capacity to carry out quite different mental operations. Psychologists soon found that a high degree of fatigue might be developed in mental tasks without affecting the strength of grip or speed of reaction at all. Therefore the interpolated task method has been given up in favor of a more direct approach which measures the amount of work in the task itself accomplished in successive units of time. Thus, if we wish to know how much objective fatigue will result from two hours of work in multiplication, we divide the total period of work into convenient units of time and find how much is accomplished in each successive unit. The decrement in accomplishment

from unit to unit is taken to be a measure of the developing fatigue. This is the continuous work method.

If there has been no change in incentive or in the other conditions of work, it is a fair assumption that the decrement actually does represent a loss in capacity to perform the task. We must be cautious, however, in assuming that this loss in capacity is all a matter of physical change. It may be a change in the worker's attitude toward the task. But to the extent that this changed attitude results from the work itself and directly affects his ability to keep on working, it is a loss of capacity in the broad sense. To be sure, we might be able to improve his attitude and, by so doing, increase his output, but this is also true in the case of physical exhaustion. Marching troops utterly weary from long exertion will straighten up and step off with a light tread when martial music is played. Football players, physically exhausted from a hard-fought game, will rally and fight like fiends in the last quarter after a pep talk from the coach. It is not safe to conclude that, because extra stimulation brings greater accomplishment, the state of fatigue which preceded it was unreal or imaginary.

Kinds of Objective Decrement.—There are a number of objective ways in which a person's performance may deteriorate. He may slow down in rate but maintain the quality of his output. Conversely, quality may suffer while rate remains unchanged. Thus he may make more errors, or what he produces may be of a lower grade. If the worker happens to be a professor marking examination papers, he may become more lenient in grading because of disgust with the task after working at it for several hours. If he is an executive, his dealings with his subordinates may be less skillful or his decisions less wise. In the case of an industrial worker, more accidents may occur per unit of time, or more material may be spoiled. In most cases, it is possible to work out an objective scale for

rating quantity or quality, and then indicate by a continuous line graph the changes in level of efficiency in successive equal units of time.

The Work Curve

The resulting graph, which is known as a work curve, enables one to tell at a glance whether performance is deteriorating or not, and how rapidly, in terms of the steepness of the decrement in the curve. In Fig. 3 are reproduced three actual work curves, each representing a different criterion of performance. In each case the task was writing the letters of the alphabet. The first curve is for rate, which is shown as changes in the amount accomplished in successive units of time, though it might equally well be expressed as changes in the time required for successive equal units of work. The second curve is for accuracy, that is, changes in the number of errors made in successive units of work. The third represents changes in quality of output. To obtain this graph, it was necessary to rate the quality of successive units of output in terms of the change in the size of the letters written longhand, because as the quality of the handwriting deteriorated, it became larger and more scrawly and there were fewer letters per line. Sometimes we must depend on the subjective judgment of one or more persons as to the quality. This can be done on the basis of a scale of values, such as excellent, good, fair, poor, and very poor. A more objective way is to compare the work product directly with standards if any are available.

Estimating the Decrement

If the course of a work curve is fairly consistent throughout, with no erratic ups and downs but a steady slope, it is a

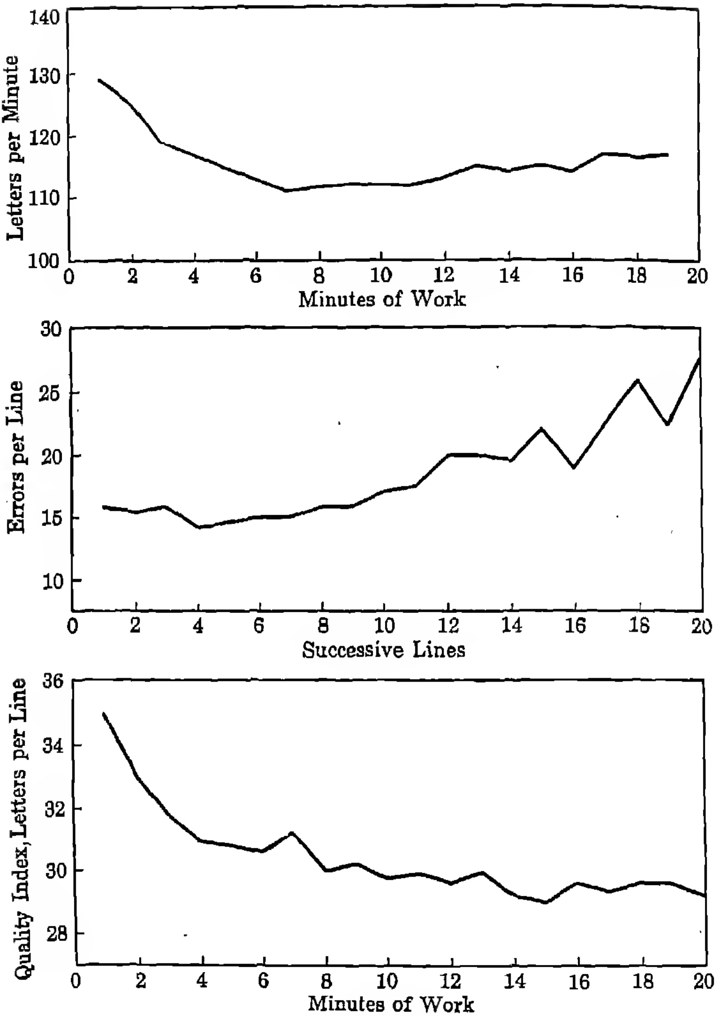

FIG. 3.—Work curves for rate, accuracy, and quality in writing or typing letters of the alphabet. (Adapted from Robinson and Bills, Two factors in the work decrement, *J. Exper. Psychol.*, 1926, 9, 415–443.)

simple matter to compute the total decrement during the work period by subtracting the value of the last unit of work from that of the first unit. If it is desired to express the decrement as a percentage, the remainder from this subtraction is divided by the value of the initial unit of work. For instance, the answer 60 would mean that there was a loss of 60 per cent of the initial efficiency. But when the work curve is very irregular, the first and last units do not necessarily indicate the general trend. The first unit may be abnormally high or low, because of some disturbing factor at the moment, and therefore may not be a reliable indicator of the initial performance level. The last unit may be erratically high, thus concealing the full amount of decrement. Under these conditions, it is preferable to divide the curve into two halves and subtract the average value per work unit during the second half from the average value per unit during the first half.

The above procedures are safe enough for computing decrements in tasks which are so familiar that little or no improvement from learning is made during the work period. But we often wish to study fatigue in a task in which a worker has had little or no previous practice. It is obvious that the practice he has during the work period will raise his level of output, and that this will be reflected in the curve by an increment above the initial level. At the same time he will undergo fatigue from the continuous work, and this will tend to introduce a decrement into the curve. The result of these two opposing influences on the curve may be to conceal the decrement altogether if the practice effect is very great, or partially to mask it otherwise. Therefore the methods suggested above for computing the fatigue decrement are not applicable to this situation because they will give a false impression of the true state of affairs. Thorndike suggested a way of getting around this difficulty. He pointed out

that any decrement resulting from fatigue is recovered from after a reasonable amount of rest. On the other hand, any improvement from practice tends to persist. Accordingly he suggested that a later test of the worker's performance level be made after a suitable rest period. This new level would indicate how well he can perform when there is no fatigue, and at the same time it would show the effect of the practice gain. Therefore, computing the difference between the level at the end of the work period and the level reached in the test following the rest gives a true measure of the amount of fatigue decrement that has accumulated during the work period. The formula is very simple, as follows: Level after rest *minus* level before rest *equals* fatigue decrement.

In view of the fact that there are several criteria of efficiency, speed, quality, etc., a word of caution should be said here against measuring either speed or quality alone, without also considering the other. One is meaningless without the other. Some workers sacrifice speed for the sake of maintaining a high quality of work, while others tend to sacrifice quality for the sake of getting a lot done. Sometimes one is more important than the other. This depends on the requirements of the particular job. But it is never safe to conclude how much fatigue has occurred in a work session if exclusive attention is given to only one criterion. For example, a worker may begin at a level of speed which is below his capacity because he is very painstaking. As he becomes fatigued, he may maintain the same rate by gradually allowing his accuracy to deteriorate. We might conclude, by considering only the curve of rate, that he had suffered no decrement. This would be an entirely false inference. On the other hand, there is no reason for speed and quality always to show opposite trends. In fact, tiredness often appears as a decrement in both. It would be helpful if the two could be combined into a single curve of efficiency, but this cannot be done satisfac-

torily. One suggested method is to plot the number of units done correctly, or up to standard, in each successive unit of time. But this assumes that the only disadvantage of errors is the time wasted in making them, which may or may not be true.

Making Use of the Work Curve.—The methods of studying the course of efficiency and estimating fatigue which have been outlined above were devised for laboratory studies, but they have been used a great deal in industry for studying production methods. However, our purpose in introducing them is rather to give the mental worker a method for studying his own performance so that he can understand himself better and both raise his efficiency and guard against excessive fatigue. Every person should know his objective fatigue curve so as to plan for the most effective and, at the same time, the most hygienic work program.

Important Features of the Work Curve

There are wide differences in the work curves of different persons, and they seem to be related to underlying differences in personality. Some individuals seem to be able to reach a working tempo at which they can continue for long periods before the acute fatigue decrement appears; others expend their peak energy early, and thereafter show a gradual decline. But certain common features appear in the curves of all workers, so that it is possible to speak of the typical curve of work. These features will be taken up separately.

Is there a "natural" rate of work for each person, at which he is most efficient? Perhaps there is, although wide changes can be produced in the rate which workers choose merely by setting a pace until it becomes habitual. Mace (7) found that the ratio of a person's "natural" rate to his maximum rate is

far from constant. Wyatt (13) has suggested that it is possible to establish, for any given individual, a measure of his maximum capacity under the most favorable standard conditions by determining his highest work rate for a period of five minutes. Using this as a standard, one can measure the influence of any single or combined group of factors detrimental to his efficiency by calculating the difference between his standard rate and his average rate under the unfavorable conditions. Applying this technique, Wyatt found that one worker might be almost twice as susceptible as another to unfavorable factors in the work situation, and the difference between a given person's maximum and average rates might be as much as 38 per cent. But there is a serious fallacy in using five minutes as the standard period. Anyone can maintain a higher level for a short spurt than he can possibly hold over a long period of work, even under the most favorable conditions. That is why we have what is known as the "initial spurt" in work curves, a feature which we are about to discuss.

Kraepelin (6), a pioneer in the study of mental work, discovered several characteristics about the course of efficiency as shown in the work curve which he named and described. The most important of these are Initial Spurt, Warming-Up, General Decrement, Adaptation to Fatigue, End Spurt, and Compensatory Spurts. Thorndike (12) later criticized all of them on the ground that they are not universally present but often fail to appear, and that the curve of work is really almost flat. But this is certainly an exaggeration. These characteristics invariably appear in some kinds of work. A knowledge of them is essential to an intelligent interpretation of the meaning of work curves.

Initial Spurt.—Most persons have been found to be very poor estimators of their own capacity to accomplish work. Filter (4) obtained estimates from subjects of the amount of

work they could do in three minutes in a large variety of tasks involving controlled association, memory, and acts of skill. He found no relationship at all between their estimates and their actual performance. Ability to estimate correctly is not a matter of intelligence, but good performers seem a little better able to judge correctly how much they can do than poor performers. It is because of the inability of workers truly to estimate their capacity that there is a decided readjustment in most people's work curves during the first few minutes. They are quite likely to plunge in at a higher rate than they can maintain and, as soon as the initial zeal wears off, a compensatory slump occurs. This high peak right at the start of work is called the "initial spurt." The drop that follows it may be so severe that nearly half the entire loss shown on an hour's work curve occurs during the first five minutes. Hence any prediction about the future course of the curve based on this initial period is very misleading. Two of the curves in Fig. 6 show initial spurt. After it is passed and the readjustment has taken place, the worker settles down to a rate that he can maintain for some time without further loss. Apparently the size of the initial spurt is not affected by the degree of familiarity with the task. Greater familiarity does not lessen the amount of spurt, for it recurs at the beginning of each day's work and may even become more pronounced as time goes on.

Warming-Up.—Under certain conditions, a surprising thing happens in work records. There may be an actual improvement of quite sizable proportions in performance level which goes on for as much as twenty minutes to a half hour or more. It would seem like a contradiction of the theory that mental work is fatiguing, if it were not for the fact that physical work curves show the same tendency. In fact, it is easy to find analogies in the field of athletic sports. Baseball players go through warming-up maneuvers with the ball be-

fore the game begins. An explanation of the effect in the case of physical exertion has been given in terms of metabolic changes. Physiologists claim that a small amount of lactic acid, which is one of the products of muscular work, acts as a stimulant to the tissues, temporarily increasing their capacity. Can the same thing be true of the nervous system? If so, we have a partial explanation of the appearance of warming-up in mental work. Robinson and Heron (11) have shown that it does not occur when the continuity of the task is too great and that it is greatly exaggerated when frequent short rests are allowed, say a two-minute rest out of every ten minutes of work. Heron (5) found that when the mental task consists in memorizing lists of words there may be an improvement of as much as 30 per cent in the rate of learning. There is a decided difference between this "warming-up" effect and the improvement obtained from practice, which is the result of learning. This difference is brought out by the fact that warming-up quickly disappears after a rest, just as fatigue does, whereas the practice effect carries over to the next day or much longer. It is necessary to warm up again at the beginning of each work period. This discovery has some important implications for the psychology of efficiency. One is that if a person's work is of such a nature or is arranged in such a way that it must be concentrated into short periods, he will find that he has to take time to warm up each time he resumes the task after a break. Therefore he should take pains to plan his routine so that the periods of work are at least long enough to derive some benefit from the warming-up that occurs within each period. Otherwise, if he stops too soon, his average level of efficiency will be lower than it might be. Ordinarily, for optimum efficiency, a work period should be at least an hour long.

Another important conclusion to be drawn from the discovery of the principle of warming-up is that highly homo-

geneous work should be punctuated by frequent short pauses in order to allow warming-up to take place. In this way it is possible to maintain the output level at a higher point. Very short pauses promote warming-up. Long rests interfere with it. That is why busy executives and persons who must be interrupted a great deal, yet whose work is of the type that requires a long warming-up period to reach maximum efficiency, have a serious problem of adjustment to solve. Fortunately, experimental studies show that it is possible to adapt to interruptions after a time, so that they gradually lose their disruptive effect.

General Decrement.—General decrement is the most constant feature of work curves. In spite of all variations large and small, if the work period is sufficiently long the average performance level in the second half will be lower than that in the first. There are certain exceptions to this. For example, if a rest is introduced just at the point where the decrement begins to appear, the work may be continued for long periods with no visible loss. But continuous unbroken work is certain to show a drop in efficiency after a time. An apparent exception to the rule occurs when the practice effect during the work period is so large as to conceal the fatigue effect. This may result in either a curve which is flat or one which rises slightly throughout. But we have already indicated, earlier in the chapter, how it is possible to demonstrate that there is really a concealed decrement in such curves. This can be done by taking a work sample after having the subject rest for a while. The level of efficiency is now found to be considerably higher than at any time during the previous work session, because the rest has removed the concealed fatigue.

Our knowledge of the general decrement is derived in large part from the studies of mental fatigue which several heroic experimenters have made upon themselves. They sub-

jected themselves to long periods of grueling mental effort so that they could observe every aspect of it, including their conscious experiences during the ordeal. Let us compare two early studies because of the very different results obtained in them. Arai (1) began doing four-place by four-place number multiplication problems "in her head" at 11 A.M. and kept it up until 11 P.M. with time out only for tea and a light lunch. She had previously given herself practice in this difficult task

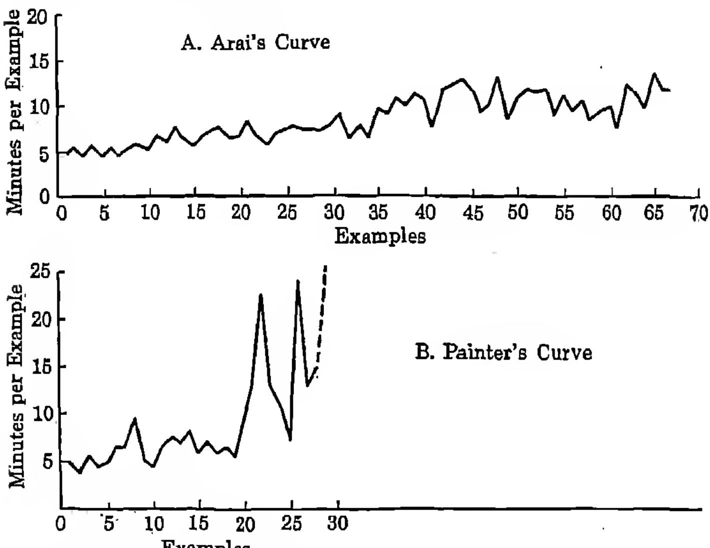

FIG. 4.—The work curves of Arai and Painter for mental multiplication. (Adapted from Arai, in *Teach. Coll. Contrib. Educ.*, 1912, 54, 91, and Painter, in *J. Educ. Psychol.*, 1916, 7, 32.)

until she was able to do the problems correctly. She used a pencil to write down the final answer to each problem but not to record any partial products. If she paused briefly between completing one problem and starting the next, her report does not say so. The objective work curve shows a decrement during the twelve hours of work amounting to ap-

proximately 50 per cent. It is a combination speed-accuracy curve, since errors were converted into time by penalizing ten seconds for each wrong multiplication. The time taken per example increased from about 5 minutes for the first one to about 11 minutes for the last, or sixty-seventh, which terminated the day's work. The variability of performance increased considerably in the second half of the work period; this is obviously a fatigue symptom, showing loss of control. But the remarkable thing is the small amount of decrement for such a long period of work. Arai suffered no serious depression in her feeling-tone, nor did the ordeal markedly affect her ability to perform other kinds of mental work immediately afterward.

Contrast with this result the experimental findings of Painter (9), who began doing four-place by four-place numbers mentally at 11 P.M. on Friday, after a hard week's work. He intended to work continuously until he reached exhaustion and then to shift to easier problems, such as three- and two-place numbers. During the first hour there was little subjective fatigue, but early in the third hour it became acute. By 2:35 A.M., after 3.5 hours of work, the process seemed no longer under voluntary control; he could not do another problem. He changed to two-place numbers, and found this also impossible. In fact, every mental task he tried proved to be beyond him. When he gave up and started to go to bed, he found that the mental effort of undressing was too great and he had to have assistance. He concluded that "there is a definite and relatively abrupt appearing point beyond which mental work becomes impossible." Comparing his fatigue curve with Arai's, we find that the first example took about the same length of time, i.e., 5 minutes, but that the twenty-sixth required 25 minutes, or five times as long, and the twenty-ninth was never completed.

~~We are at once struck by~~ the contrast between the results

of these two studies. Was there some fundamental difference in the personalities of these experimenters? As a matter of fact, Arai is unique in being the first person who ever subjected herself to so grueling a test. This indicates either a strong motive to demonstrate stamina or else an unusually placid disposition. However, her study was repeated in every detail by T. W. Martin in 1930 at the University of Toronto, with similar results. On the other hand, Painter's condition after four hours appears to have an element of hysteria in it. Probably the truth lies somewhere between these two extremes. At least, Arai herself reports more rapid decrements obtained from a group of sixteen students who worked on two-place numbers for periods of two or three hours. An assumption is made in both Arai's and Painter's studies that needs to be critically examined. They both used multiplication of large numbers "in the head" because this seemed to be about the most difficult task they could find; but there is evidence, which we shall consider in the next chapter, that tasks which seem the most difficult are not necessarily the most fatiguing. If they are complex, they employ so many different mental processes that no one process is continuously exercised. And a further point is that such complex processes continue to show practice gain after long periods which would obscure the decrement that might otherwise appear.

The results we have discussed and innumerable others support the conclusion that individuals differ widely in susceptibility to fatigue and that a given person shows quite different rates of fatigue in different types of mental work.

Adaptation to Fatigue.—Well-practiced mental tasks are more resistant to fatigue decrement than novel ones. There seems to take place an adaptation of the neuromuscular elements involved which is analogous to that undergone by muscles that are exercised periodically. There is a residual effect which enables these elements not only to perform the

work more skillfully but to suffer less fatigue in the process. Dwelshauvers (3) attributes this in part to the tendency of well-practiced persons to so automatize the operations in the task that it can be carried on without conscious attention. This leaves the higher centers free to rest, and thereby builds up resistance against fatigue. He has discovered that it is the more intelligent people who are most successful in building up such resistance.

End Spurt and Compensatory Spurts.—In the discussion of facilitation in the preceding chapter, the theory was expressed that there is an energy level of the brain which is the resultant of its own intrinsic energy combined with the various external and internal facilitators which are acting at the time. It was suggested that emotions and motives act as facilitators. No better illustration of this effect can be found than the phenomena of end spurt and compensatory spurts. End spurt is the tendency for workers to increase their rate markedly when they realize that the end of the work period is near. Sometimes this increase amounts to the recovery of as much as 40 per cent of the efficiency lost during the entire period. It has been used as an argument to prove that the decrement in work curves is not true fatigue because so much of it disappears when a new incentive is introduced. But an added incentive acts on the thinking machine like a dose of strychnine. Under its stimulation, the capacity level of the individual is altered. This is no proof that the preceding state of fatigue was unreal. Since end spurt appears so often in work curves, it is unsafe to use the last five or ten minutes of performance in computing the overall decrement in the curve, because some of the decrement has been canceled artificially by the spurt.

Compensatory spurts appear right after periods of distraction or interruption, or whenever the organism becomes aware of a temporary slump in output. They apparently rep-

resent the operation of a set, which is subconscious, to maintain a certain level of performance. They depend on a tendency which is common to all of us, to live up to our past record. Morgan (8) has called attention to the tendency to put forth greater effort whenever resistance is encountered. He considers it a basic principle of nervous organization, and probably of reflex origin.

Variability.—There is a change in type of performance which appears with the onset of fatigue in work that is highly significant but is not included in the usual criteria of decrement. This change is toward a greatly increased variability in output from moment to moment, with wide swings from good to poor performance. A glance at the twelve-hour work curve of Arai (1) indicates that this variability began to manifest itself after about the first hour and became marked after the middle of the work period. For example, during the first hour the variation in time from problem to problem was never more than a minute. In the second hour it increased to two minutes, and in the last half of the curve fluctuations of four or five minutes occur. This means that, toward the end of the work period, Arai might take eight minutes for one problem and twelve minutes for the next one. Even if we consider relative rather than absolute variability, the increase in fluctuations is exceedingly large. This indicates loss of control. There seems to have been a breakdown in the controlling set which ordinarily keeps a person working along on an even keel. This change is very characteristic of work curves carried to the point of considerable fatigue and it has practical significance for workers, because when these wide fluctuations in performance set in, there is an uncertainty, an unpredictability about behavior that makes accidents more common and judgment less reliable. To explain this increased variability satisfactorily requires

introducing some further principles of fatigue which we shall now discuss under the subject of "blocking."

Blocking and Fluctuations of Energy.—The interesting fact was recently discovered that the thinking machine does not operate continuously in performing mental work but instead functions intermittently. There are recurrent pauses or gaps in responding which may occur as often as five times a minute or as seldom as once in two or three minutes. These pauses indicate a blocking or suspension of the action of the brain for that particular task; they recur in a rough pattern which seems to approximate periodicity. Different people display different frequencies of blocking, each individual seeming to have a frequency which is typical for him under constant conditions. But a person's frequency varies for different kinds of mental work (2). Simple repetitive operations like adding pairs of numbers successively show a higher frequency of blocking than more complex mental operations like solving problems in reasoning by analogy. A person may not be aware of the blocks, particularly if the units of work are so long that the blocks fall within completed units rather than between them. Practice in a particular mental task tends to reduce the frequency of blocking in that task. Fatigue, on the other hand, greatly exaggerates it; the blocks or pauses become longer and more frequent. At the end of an hour's work they may occur with three times the frequency shown at the start. When errors are made, they seem to fall in the moment just before a block. The worker tends to speed up after each block and then to slow down just before the next one. After a number of blocks have occurred at intervals of twenty or thirty seconds, there will follow a period of two or more minutes without any blocks, after which they will again appear at the original frequency.

People who fatigue rapidly also show the greatest increase

in blocks. Physical conditions which depress the energy of the brain, such as an insufficient supply of oxygen in the air breathed, cause the blocks to lengthen into long pauses of a minute or more between responses. This is clearly indicated in Plate 4, which shows the record made by a subject responding manually to color stimuli while breathing different concentrations of oxygen. Stimulating agents reduce their frequency and length. Psychotic patients whose nervous systems have undergone considerable deterioration show very long and very frequent blocks. Persons of subnormal intelligence show an extremely rapid increase in blocking after a short period of mental work of even the simplest type.

There are a number of other mental phenomena which seem to be related to this blocking tendency. One of these is what has been called the fluctuation of attention. Long ago it was observed that if we try to attend steadily to a very weak sound or a very weak visual stimulus, it will disappear periodically and then reappear. But the frequency of fluctuation of auditory and visual stimuli is not the same, so they cannot both be due to the same attention wave; the frequency must be affected by the processes in the sense organ and tract as well. The resulting wave of reinforcement and dimming in the sensation would be a composite effect of the brain and sensory tract and perhaps of still other factors. It has also been observed that a person cannot hold his attention on a single item, such as a dot on a page in front of his eyes, for more than a few seconds at a time. His attention will shift to other items in spite of all his efforts to prevent it. This gives a sort of periodicity which has also been called fluctuation of attention. All these facts point to a rapid exhaustion and recovery process going on in very limited parts of the nervous system recurrently whenever they are used continuously at one time.

Is it possible that we are here dealing with an effect of the

neurological principle of refractory phase in a new guise? This principle was stated in Chapter I in the discussion of the nature of the nerve impulse. After an impulse is excited in a nerve, the nerve must recover before it will respond to the next stimulation. This brief rest period, which is less than one-hundredth of a second and comes after each response, is the refractory phase. But in complex neural arcs such as are involved in making a simple response to a simple stimulus, say pressing a key when a light flashes, the refractory period is much longer; it may be a second or two in length, but it still occurs after every response. No, it seems probable that when a person is continuously reacting as fast as possible, these separate refractory states are not completely recovered from; they accumulate a debt which has to be paid by a longer rest pause after several responses. This would cause the block which, as we have pointed out, actually does occur every half minute or so. It would also cause the fluctuations of attention, because a shift to a different subject would accomplish the same result as a block or pause in permitting the mechanisms to recover. As we shall see in the next chapter, the kinds of mental work which are the most monotonous, that is, involve repeating one mental operation over and over again, are the ones which show the greatest amount of blocking.

In addition to the relatively short fluctuations of energy which we have discussed, there are longer fluctuations that occur over several minutes, and still longer ones which take an hour or more to complete one cycle. The difference in level between the high point and the low point in an hour is marked, even if the matter of a general decrement is disregarded. According to Phillpots (**10**), who studied these fluctuations for years, there are also waves covering several hours, and still longer ones which include several days in each wave. Whether all of them can be explained by the

same principle is very doubtful, but it is a great advantage to know about them, for several reasons.

First, a person who knows his own block frequency can plan his responses so as to avoid making mistakes. It has been possible to cut down on both errors and blocks by determining an individual's block frequency and then instructing him to adopt work rhythms which bring natural pauses at comparable intervals.

Second, it may be possible to predict how rapidly a given person is likely to fatigue in a given kind of work or under given conditions, by determining how frequently he blocks. Sometimes there will be no reduction in rate, that is, in number of responses per minute, and no increase in errors, because the blocking has increased so much that it compensates for the fatigue that has developed. In these cases the onset of fatigue is concealed by every method of measurement except the method of counting blocks.

Third, a knowledge of the longer "attention waves" or cycles of efficiency is valuable to a mental worker because it enables him to lay out his work in periods of the right length to take advantage of the crest of the curve and to avoid the trough. A thorough study of one's own curve of work can yield dividends in added efficiency. There is probably nothing inevitable about the shape of the work curve of a given person. It can probably be modified to fit better the needs of a specific job or situation by deliberate effort plus a lot of practice. The administrators who plan the daily work schedules of their subordinates should first know these workers' individual rhythms of efficiency in order to do a more intelligent job of planning. Directors who plan radio programs, etc., should know something about the average attention fluctuations of listeners. Practical experience in these matters is a guide to the old-timer, but it can profitably be supplemented by a dose of theory.

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Chapter IV

MENTAL WORK AND MENTAL FATIGUE (*Con't.*)

In the preceding chapter the objective method of studying variations in mental efficiency was explained, and some important discoveries about the curve of work based on this method were discussed. In the present chapter we shall see how the course of the decrement varies with the kind of work, the subject's attitude toward it, and his age, intelligence, and personality pattern. We shall also examine the organic method of studying fatigue, and consider the implications of the data which have been obtained in this way.

Is All Mental Work Fatiguing?

The tendency to think in terms of loose analogies is natural but sometimes misleading. We become acquainted with physical fatigue earlier than with the mental variety. This leads us to look for analogies between them. But how far is it safe to carry such analogies without falsifying the true nature of mental fatigue? Physical work reduces to a simple matter of moving weight through space, and could very well be expressed in ergs. It follows that what makes physical work hard or easy is the amount of weight one has to move, and how far and how fast one has to move it. Gilbreth (10) showed that this is partly a matter of how the arms and legs and trunk of the human body are employed as levers and fulcra. On this basis the efficiency engineers worked out the most economical motions of the worker's body in terms of units called "therbligs." Each complex act could be broken down into so many therbligs, or basic movements. (The

name "therblig" is the name of the originator of motion study methods in this country, Gilbreth, spelled backward.) It is now possible to compute the least number of therbligs which workers will have to expend on a given job, even if it is as simple as packing chocolates.

Can we, reasoning by analogy, do the same thing for mental work? Can we compute the mental therbligs for a given job? The idea is intriguing, until we put it to the test of analysis. Do we have any clear mental work variables which are comparable to weight, distance, and time? What makes a mental task difficult or easy? Of course we might be tempted to beg the question and say that a difficult task is one that makes us tired. But the thing we really wish to know is what objective characteristics of a particular task make it difficult or easy. For example, persons of high intelligence can do mental tasks that those of average intelligence find impossible. Can we measure the difficulty of a task by the level of intelligence necessary to perform it? If so, there should be some relation between the effort put into it and the level of intelligence. As a matter of fact, however, very intelligent persons find it harder to spend an hour at an extremely simple but repetitive task than to solve intricate problems. Burnett (6) reported an interesting study of girls at three intelligence levels in an industrial job in England. The work assigned to them was stitching. The girls of the lowest intelligence could not learn to do the work properly; the middle group were the most efficient at it; the girls of high intelligence were so nervously affected by the boredom of it that some of them burst into tears and many were unable to continue the work. From their point of view it was hard work; a job that required more brains would have been easier for them.

This last illustration suggests another criterion of difficulty, i.e., the effort required to hold attention on the task. One

man's meat is another man's poison. The question of interest or motive enters here. If we are interested in a certain line of work, the effort required to hold attention on it is minimized. Similarly, an uninteresting task requires the expenditure of an inordinate amount of effort in concentration. We seem to be forced to the conclusion that the work itself cannot be said to be intrinsically either easy or difficult. It is the manner in which the worker responds to it. Hence, in our future discussions, this relationship will be taken for granted. We shall examine first what features of a task make it fatiguing to the average individual, and secondly, what differences between individuals affect their susceptibility to fatigue.

Characteristics of Fatiguing Work

A pioneer study in this field was made by Robinson (18), who formulated some of the principles which have been proved experimentally (19). Others have added to the list. Among these principles, the following merit discussion here: continuity, sameness, conflict, unfamiliarity, meaninglessness, and satiation. We have taken the liberty of changing the names originally given to some of them because they seemed too clumsy.

Continuity.—The thinking machine cannot operate continuously with no break or pause. Mental work which does not allow for pauses between successive units suffers a rapid decrement. In discussing the conditions necessary for warming-up to occur, we pointed out that it appears only in tasks in which the continuity is broken by pauses. Otherwise, the decline sets in from the beginning of work. The blocking tendency, already described, in which there are forced pauses or gaps in performance, is the protest which the brain makes against this intolerable factor of continuity. The only other

means of escape from it is for the mind to enter into a sort of trance, allowing automatized habits to carry on at a lower level. This is by no means an ideal condition for efficient work. A possible alternative is deliberately to break up the continuity artificially. Bills and Brown (4) tested groups of students working on highly continuous tasks under two conditions; in one, they were confronted with an unbroken page of material to work on; in the other, the page was divided into smaller units which were presented successively, one at a time. The latter yielded the larger output for the same total time.

Sameness.—Sameness is the quality of those tasks which involve repeating one operation or a limited number of different operations over and over again. When a high degree of sameness and a high degree of continuity are combined, the effect of both factors is exaggerated. We have, in such a combination, the very conditions which lead to the operation of the refractory phase principle, because the same response system is repeatedly stimulated without a long enough pause between responses to allow the system to recover. An example of a fairly easy task that has a great deal of sameness is adding pairs of digits successively. A contrasted task with considerable variety in it, even though it is complex and taxes one's mental ability to the fullest, is taking intelligence tests. Poffenberger (17) tested a group of students on each of these tasks for the same period of time. The results are striking proof of the fatiguing effect of the sameness principle. The adding showed a decrement of about 20 per cent, whereas the work on intelligence tests actually showed an improvement of 20 per cent. These results are shown in Fig. 7 (page 91).

Conflict.—The obvious remedy for the detrimental effect of sameness on efficiency is to change to a different type of work for a few minutes, say every hour or so. More frequent

changes may not be practical in an actual work situation. However, Chapman (7) found that changing from addition to letter canceling as often as every minute gave a decided advantage over continuous addition; it was 50 per cent as effective as if his subjects had actually rested every other minute. Over longer periods, such as a whole day, Miles and Skilbeck (13) increased the output of one group of workers 14 per cent by introducing a fifteen-minute period twice a day in which they worked on a different task. It proved to be better than a rest period. However, there is a very important exception to this. When, by changing from one operation to another, conflict between response tendencies is introduced, the benefit is canceled. For example, suppose a person is given a row of digits, 5 4 7 6 3 8 5 9 6 3 4, and is asked to add 3 to the first, subtract 3 from the second, add 3 to the third, etc. The decrement in a task of this sort is more rapid than it would be if he were asked to add continuously or subtract continuously. The conflict between the tendency to add and to subtract at the same time is fatiguing. But a worker can adjust to such a shift of set after a time.

Unfamiliarity.—An unpracticed task is always more fatiguing, partly for the very reason we have just discussed; that is, until the operations become thoroughly habitual, there is a conflict or struggle between correct and incorrect response tendencies. This early uncertainty disappears later with practice, and the concentration of attention can be replaced by habit controls which are almost automatic. Another reason for the greater fatigue in performing an unpracticed task is the fact that more widespread actions are called into play. Anyone who has watched a small boy beginning to learn to write knows that he first writes with his whole body, not just his fingers. His tongue sticks out and describes arcs, his legs twist around his chair, he scowls and grimaces. Contrast this picture with the same boy after he has made

the act habitual. All excess movements have dropped out. The saving in energy is tremendous. The same is true of adults. A study made by Rounds, Schubert, and Poffenberger (20) on the metabolic cost of mental work showed that practice in a task increases the output without increasing the energy expenditure, because of the saving per unit. The resulting cost per unit of production may be much less.

The person who reduces to automatic habits as many of the operations of daily living as possible can conserve mental energy for the jobs that really count. We cannot depend on chance or the law of repetition alone to form such habits for us. We must deliberately set about to automatize the routine operations of our job. Those who direct the activities of other workers should plan their work schedules in such a way as to capitalize on the principles that we have been discussing.

Meaninglessness and Satiation.—These two concepts can be discussed together because they are probably two ways of saying the same thing. Lewin (12) and his students have carried one of the pet theories of the modern German school of psychology over into the field of work and fatigue. This theory holds that people always react to meaningful wholes, not to parts. For example, if we give a piece of work to a person, he sees it as a total pattern which he feels an urge to complete. Lewin asumes that there is a law of mental action, called the law of closure, which sets up a state of tension in the brain when such an incomplete pattern is presented. This tension is not relieved until the pattern is completed. Therefore, when we give a person a piece of work, since it is necessarily an incompleted whole until he finishes it he will be under tension until it is completed, and after that the state of mental suspense will be removed and his interest in the work will cease. To use Lewin's expression, the worker is "satiated." A good illustration of this is the suspense of a person who is solving a jigsaw puzzle. He feels an urge to complete

it, but when he has done so he is satisfied and takes no interest in starting another. If a task is broken up into such small units that they cannot be reacted to as meaningful wholes, no tension is set up in the worker. Only by sheer voluntary effort can he hold himself to such a fragmented job. He is bored wth it, and his boredom is rapidly intensified, causing the steep decrement which occurs in such tasks.

In proof of his contention, Lewin cites experimental evidence to show that when people are given such a meaningless task as making vertical marks with a pencil repeatedly, they soon begin to vary them in every possible way so as to relieve the intense boredom by forming some sort of meaningful pattern. This is a plausible theory and we offer it for what it is worth. Personally we feel that it is more limited in application than the principle of sameness, already discussed. Lewin's study in which he had his subjects read the same poem over and over is a better illustration of meaninglessness.

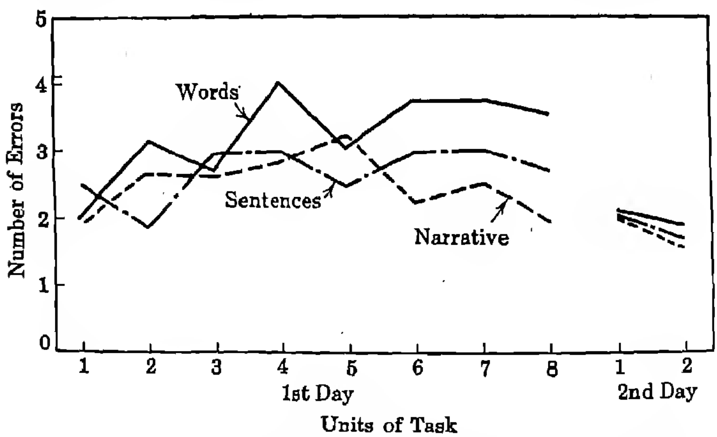

FIG. 5.—The more rapid fatigue (increase in errors) for the less meaningful or connected kind of task. Words are least connected, sentences next, and narrative most connected. (From M. F. Robinson, The work decrement as affected by three kinds of meaningfulness, *J. Exper. Psychol.*, 1938, 22, 129.)

Robinson (20) has shown experimentally that the less meaningful material is not always the more fatiguing. It all depends on the nature of the meaningfulness. If the meaningfulness is a matter of connectedness between the successive work units, then such material is less fatiguing than disconnected material. For example, she found that a subject who is given the task of reading words that are printed backward fatigues less rapidly if the words form part of a sentence or narrative than if they are discrete. The connectedness seems to help. This is shown in Fig. 5. But if he is given

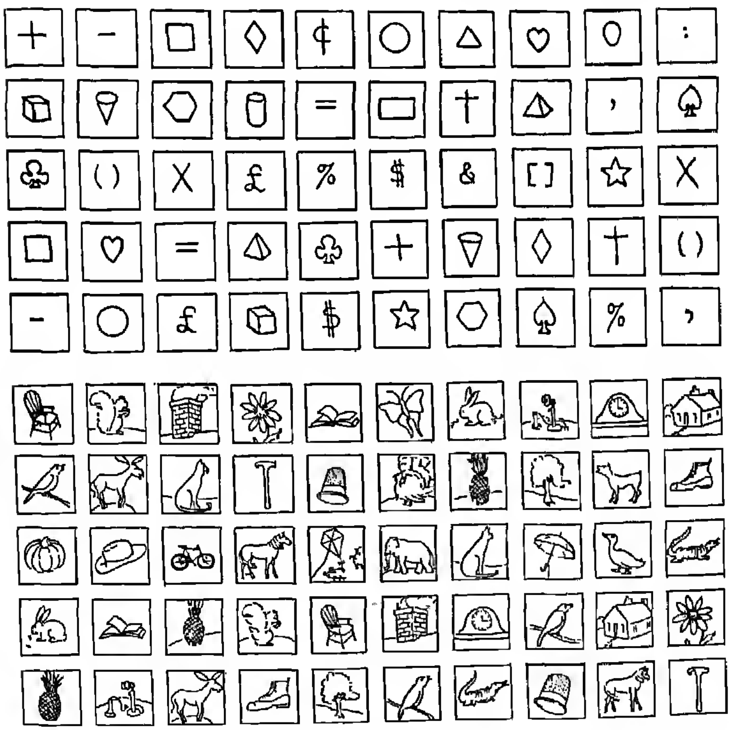

FIG. 6.—Pictorial material of two different degrees of meaningfulness. (From *ibid.*, p. 148.)

a large sheet containing rows of objects, like the lower example in Fig. 6, and is told to name them as fast as he can, he will fatigue more quickly at this task than if the sheet shows abstract symbols that are to be named, as in the upper example. In this case the more meaningful material causes more rapid mental fatigue.

Inspiration versus Perspiration.—Is there any difference between the principles of fatigue that apply to such routine mental work as is usually made the subject of experimental study and those that apply to the very different kind of mental work done by inventors, artists, writers, and those who depend on inspiration? Is the curve for creative work anything like the curves we have discussed? One psychologist (15) has obtained evidence that it is. Since quality of product is the only measure of efficiency in such work, he judged this by the power of imagination displayed, using four levels or grades of imaginative power. His plotted curves indicate the changing power of imagination during two hours of work. The curves show an early rise to a peak, which he considers the point of inspiration and which is accompanied by high excitement, and then a later decline. The only unique thing about the curve is the steepness of the warming-up rise. Creative work should illustrate perfectly the operation of Lewin's principle of closure. The closure really occurs at the point where the peak of inspiration is reached. Up to that point the psychic tension is great, but beyond that point there is an anticlimax. The decrement in the later part of the curve reflects this relaxation.

Individual and Group Differences

While it is true that everyone's work curves show fatigue symptoms, there are great differences between people in the

pattern of their decrement, particularly the steepness of onset. In this connection, we may recall the striking contrast between Arai's and Painter's curves. Arai (1) showed a steady slow decline after the first hour which was only slightly accelerated during the last hour of work. Altogether, her drop during the twelve hours amounted to about 50 per cent. Painter (16), on the contrary, showed an abrupt collapse after three and one-half hours. Fatigue did not appear markedly in his record until the beginning of the third hour. Here, then, are two quite differently shaped curves, one linear, with a slow decline throughout; the other rounded convexly, and positively accelerated toward the end. One other type of curve that has been described is concave in shape, dropping rapidly at first and then recovering later. These decided differences in the work curve patterns of different individuals must indicate deep-seated personality differences. For a given kind of work a given individual is fairly consistent in the shape of his work curve.

Other studies support the notion of personality differences. Thompson (22) concluded that one kind of personality difference involved is susceptibility to monotony. People possess this trait in varying degrees. He found that intelligence has little to do with it, and this has been confirmed by others. Thompson invented a test for the purpose of determining the degree of any individual's susceptibility to monotony. He gave his experimental subjects four different kinds of work, each divided into a uniform phase and a varied phase; the uniform phase would bring out the effect of monotony. He then measured the percentage decrement in their work curves for the two different phases, and subtracted the decrement for the varied phase from that for the uniform phase. The difference gave a single score which indicated the effect of uniformity; i.e., how much his subjects were affected by

monotony. He found that the scores his subjects received on this test agreed pretty well with the opinions people had about them and with their past histories of behavior. Are we to conclude from this that some persons are temperamentally unfit for monotonous work? If it were only the highly intelligent who showed this trait, it might be disregarded because they usually succeed in passing on the tedious routine to others. But for the average individual it is a serious handicap. Fortunately, psychologists agree that personality traits are not unchangeable but can be modified. People who discover that they have a high suceptibility to monotony can increase their efficiency by making a conscious effort to change their personality pattern. It is significant that individuals who show the most skill in doing a particular type of work are least affected by boredom in that activity, regardless of their intelligence level. Some of the work connected with scientific research is tedious beyond description, yet the scientist seldom complains of boredom. This shows that it is in large part a matter of attitude. Things we do well interest us; it follows that if a person perfects himself in a job, the monotony of it will be lessened.

Another important difference between people which shows in the pattern of their work curves is the variability factor. Some workers are constitutionally erratic, others are stable by nature. The curves for the first group display wide swings, and usually also a high incidence of errors. Those for the second group approximate a smooth line. These tendencies seem to be associated with certain differences in social traits, such as timidity versus aggressiveness. Timid, repressed persons tend to be more consistent and steadier in performance. On the other hand, confident, aggressive people are faster, more erratic, and more variable. They have large initial spurts and more rapid decrements in consequence. Timid persons, on the contrary, tend to conserve their energy and

work along on an even keel. As might be supposed, the confident, aggressive person tends to block more often.

One of the important factors that affects the rapidity of the onset of fatigue is age. Children show a tendency to develop decrements in their work curves very rapidly; they are incapable of long-sustained effort. This tendency is gradually overcome with increasing age. Feeble-minded individuals are much like children in this respect. They lack the volitional control that is required to hold their attention to a task continuously. This is true for physical exertion as well as for mental activities, because the element of volitional control is such an important factor in sustained muscular effort. This shows up clearly in the experiment with the ergograph. The ergograph is an instrument designed to record the continuous work of an isolated muscle group pulling repeatedly against a weight. The record thus obtained is called an "ergogram." It shows how strongly the subject pulls on each successive stroke. Usually the pulls become rapidly weaker until they stop altogether after one hundred or so. The feeble-minded show rapid decrements in their ergograms. (See Fig. 8, page 109.) Normal adults differ greatly from one another in the steepness of the drop in their ergograms. It seems to depend much more on fatigue of their volitional control than on mere muscular exhaustion, because long after they have ceased to be able to pull against the weight the muscle can be made to contract vigorously by stimulating it directly with an electric shock. In Chapter XII evidence from experiments with suggestion will be cited to show that an ergogram can be increased or decreased merely by telling the subject that he will be able to go on further or that he will become exhausted. This shows how much our muscular strength depends on our mental determination. There is no room for "spinelessness" in a program calling for a high level of personal efficiency.

The Organic Method of Measuring Fatigue

The second of the major methods of measuring fatigue from mental work is the organic method. This consists in studying the physiological changes that occur in the body during and after a period of work and that are caused by the extra energy requirements of the mental effort. This would seem to be the most direct approach to the problem, because the condition responsible for lessened output and lowered feeling-tone after continuous work, must be an organic change. But there are so many technical difficulties, and so many opportunities for error in any measuring method yet devised for studying the organic changes, that this approach seems to be entirely impractical for anyone except the specially trained research worker. The reason for describing the method here is to satisfy the reader's curiosity as to what can and cannot be found out by its use, and to give a clearer understanding of the way in which such facts as the metabolic cost of noise, the energy loss from emotional friction, etc., have been discovered.

The main difficulty with the organic method is that the changes in bodily condition caused by mental work are so subtle in comparison with the changes due to gross muscular activity that the latter mask the former. For example, so much more exercise of the gross muscles is involved in standing up or moving around than in thinking that any comparison between the metabolic rates before and during mental work is misleading. The rate is likely to show a slowing down rather than a speeding up during the period of thinking. This is because a person usually sits down to think and remains fairly quiet for a long time; whereas before he has been moving about and exerting muscular energy. Imagine the difference between the amount of moving about that

Arai did when she sat all day and worked problems in her head, and the amount on any ordinary day in her life. The only fair comparison would be between a period of mental effort and an equal period of just sitting quietly. In both cases, a drop should be expected from the previous level because of the artificially quiet posture. But the drop should be less abrupt when mental effort fills the period. This assumes, of course, that it is possible to set up a fair control period, i.e., one in which a person just sits and engages in no mental activity whatsoever. The ordinary daydreaming carried on by a mind that is supposed to be resting quietly can be very emotional and energy-consuming. It is only by supressing all thought that a person can find out what his true resting metabolic rate is. This is the only fair basis on which to compute the increased energy expenditure caused by superimposing mental work upon the resting state.

Pulse, Temperature, Breathing, Blood Pressure, and Volume.—All these organic processes vary with variations in metabolic rate. Therefore, by measuring changes in them, a rough estimate of energy expenditure can be obtained. The technique for making these measurements is so simple that almost any careful worker can obtain reliable results with ordinary clinical equipment. However, few of the studies actually made have taken pains to insure the precautions pointed out in the preceding paragraph. An early and often-quoted study by Benedict and Carpenter (3), which showed an average pulse rate of 79 beats per minute for students during mental work on college examinations as compared with 74 beats per minute during an equal period of rest, was justly criticized by Dodge for this reason. He (8) pointed out that the conditions of the so-called rest period were so exciting that the mental work of examinations could not be expected to increase the pulse markedly. In fact, on the basis of data of his own, he says: ". . . Provided one starts from a pre-

experimental condition of relatively complete physical and mental relaxation, every new mental or physical activity is correlated with an accelerated pulse." He also found that when the periods of thinking in an examination taken by students were measured separately from the periods of writing down answers, the students often showed as fast a pulse rate or an even faster one in the former than the latter. Recently Benedict and Benedict (2) obtained increases in heart rate from 60 during a resting state to 65 per minute during an hour's mental work.

Temperature changes, on the other hand, are so variable and so slight that the method is not to be recommended. Breathing is affected in both rate and depth. Skaggs (21) compared breathing rate and pulse during mental multiplication, relaxation, and expectant attention induced by waiting to be given an electric shock. The mental work caused very shallow but rapid breathing; the pulse rate increased from 80 per minute in the relaxed state to 87.5 in the work period. Expectant attention produced a variable breathing record with deep inhalations, and an increase in the pulse rate to 91.5. To the degree that thinking involves subvocal speech, breathing becomes irregular. Blood pressure and volume have to be taken continuously to show anything. Gillespie found they increased from mental work. This method has more value for disclosing temporary states of excitement, alertness, or emotional reactions than for measuring energy expenditure over periods of time.

Studies of the Products of Metabolism.—Whenever the body is called upon to use extra energy, there is a corresponding increase in the waste products which are thrown off. These products can be found most conveniently either in the expired air from the lungs, in the venous blood, or in the urine. The two methods most used for measuring them are respiratory calorimetry, which consists in sampling the ex-

pired air and determining how much carbon dioxide it contains, and chemical analysis of the blood. Both require elaborate apparatus and technical skill; the ambiguity of the findings makes these methods entirely impracticable except for laboratory research. The respiratory method requires that the person being tested wear a mask over his face and breathe into a rubber chamber so that his expired breath can be collected and chemically analyzed. A careful record must be kept of the amount of oxygen breathed in and of carbon dioxide given off so that a ratio can be computed between oxygen intake and consumption. This is called the "respiratory quotient." The results which have been obtained by this technique in the case of mental work are somewhat contradictory. Different scientists apparently disagree as to the amount of increase in the metabolic rate caused by given amounts of work. Numerous recent studies report increases all the way from zero up to 28 per cent or more above the resting metabolism. Some find that the amount of muscular work involved does not cause any significant increment in the total, but that the rate is directly proportional to the amount and difficulty of mental effort. Others report that little remains when the muscular component is subtracted. Probably the fairest estimate would place the increase conservatively at about 4 or 5 per cent in tasks in which the muscular element is minimal. This is small, but it may be extremely significant when we consider that it means intense activity in a very limited set of organic processes. It would be senseless to argue that because so small a percentage of the body metabolism is involved in brain activity, we can safely ignore it. This would be analogous to saying that because the electric clock in our home uses so little current as compared with the electric refrigerator, the clock's requirements for electricity can safely be ignored. A very slight increase in the total body rate of metabolism could well indicate a tremendous increase in the

rate of activity of the brain cells and could mean an important amount of wear and tear on the mechanisms involved.

The higher rate of energy consumption resulting from mental work appears early in the work period and remains at the same level during the entire session. After the work is finished, a recovery period sets in, during which there is a very gradual return to the normal rate. Sometimes, however, the rate is higher during this recovery stage than during the mental activity. This is because it takes time for the body to throw off the waste products. Work on unpracticed tasks or under conditions of distraction or emotional strain incurs a much higher metabolic cost (20).

The blood analysis method gives data which support those obtained from respiratory calorimetry. More carbon dioxide and less oxygen are found in blood leaving the brain than in blood entering it. The changes for the body as a whole are small; but decreased sugar has been noted, as well as small increases in inorganic phosphorus and a lowered alkaline reserve. Goldstein (11) could discover no significant changes after an hour and a half of mental work that could not be attributed to the muscular element involved. However, Brown and VanGelder (5) found that students facing a comprehensive medical examination showed a marked increase in the amount of sugar thrown off by the urine, both before and during the ordeal. Possibly emotional strain rather than intellectual effort accounts for this. But is mental work ever entirely free from emotional strain?

Measures of Muscular Tension and Skin Resistance.—It has been known for some time that any increase in mental effort involves increased tension in the muscles. Even the most casual observation shows this. We scowl, tense our jaw muscles, and drum with our fingers or feet. In a study of mental work under distraction, Morgan (14) was able to show that a person may actually accomplish more than under

quiet conditions, but this is because he exerts more effort, as is shown by the increased tension he uses in responding to the task. Morgan measured this increased tension by recording the exaggerated pressure which his subjects exerted on the keys used in making the responses. Freeman (9) went further and demonstrated that tension and restlessness increase as fatigue accumulates during protracted periods of work. He had his subjects do addition of four-place numbers for five consecutive sessions of 90 minutes each. The results indicate that as the individual's energy is depleted he involuntarily increases his effort, and this is reflected in higher tension and likewise in greater restlessness. The increased effort of which the tension is a sign may compensate for the lowered efficiency from fatigue and actually maintain the output at a constant level, but only at an increased cost. Freeman used an improved device for measuring tonus. He recorded muscle thickening by a method called the "deformation" method. A lever is pressed against the tendon and attached to a second lever equipped with a small mirror. As the tendon thickens from the contraction of the muscle, the mirror turns, and a beam of light reflected from it can be photographed. The swings of the mirror can be made to amplify the changes in tendon deformation 150 times. Simpler but less reliable is the method in which the subject holds a pneumatic bulb in his left hand while he does mental work, or writes down his responses to mental problems with a special pencil equipped with a pneumatic device for recording the amount of pressure he exerts on it. Still another method is the "action current" method. This is too delicate to be used by amateurs. It consists in obtaining action potentials, i.e., electric impulses, from the muscles through electrodes attached directly to them. Some instrument has to be used for amplifying and recording them. The cathode ray oscillograph is the most commonly used.

Skin resistance changes, called the "psychogalvanic reflex," may prove to be the most satisfactory of all measures of organic change. They are extremely sensitive to slight variations in alertness on the part of the subject, and seem to be peculiarly fitted to reflect such energy changes as are involved in mental effort. For example, skin resistance increases steeply during a period of relaxation, but as soon as a mental task is begun or even anticipated by the subject it drops sharply. Throughout a period of reasonably taxing mental work it remains low, showing the continuous state of nervous tension, but just as soon as work ceases it begins to increase steadily. After short periods of work the rise is rapid. With longer periods, just as the organism is slower to recover, so the resistance curve rises more gradually. If a mental task is well practiced so that a real mental effort at attention is no longer necessary and the work can be carried on automatically, this is reflected in a steadily rising resistance curve. The method is not so valuable for obtaining cumulative effects; but for showing the level of brain excitation at each moment of the working period, it is unequaled by any other device. For an illustration of the apparatus used and the results obtained by this technique, see Kirby's study on the curve of recovery from fatigue, described in Chapter VII. The necessary apparatus is shown in Plate 6.

Under-Ventilation as an Organic Component of Mental Fatigue

Before leaving the subject, we would like to suggest a few additional factors which may play a part in mental fatigue from the organic side. One of these is the insufficient ventilation of the lungs which occurs during close mental application. Thinking interferes seriously with normal rhythmic breathing; the inspirations become very shallow. It would

seem as though the oxygen requirements of the brain are so slight that this insufficient ventilation should not be of much importance. Yet the behavior of mentally fatigued persons and of people suffering from anoxemia, i.e., insufficient oxygen, is very similar. When an anoxemic subject is given pure oxygen to breathe, he recovers from his symptoms immediately and his behavior becomes normal. When a person who has been doing mental work for a long time is given pure oxygen to breathe, he likewise recovers from the decrement in his work curve and other symptoms. The author has demonstrated that the blocking tendency, which is exaggerated both by a state of anoxemia and by mental fatigue, is recovered from in both cases by breathing pure oxygen. Plate 5 shows the apparatus used in the experiment, and the effect on the blocking tendency. The subjects breathed ordinary air for 45 minutes, then pure oxygen for 15 minutes, then ordinary air again. The drop in the curve during the breathing of pure oxygen shows a decidedly beneficial effect. The blocks become shorter and less frequent. Pure oxygen has no such beneficial effect on an unfatigued person. Can it be that in mental work the breathing is so shallow and irregular that, over a period of time the worker is really suffering from a slight condition of anoxemia? It is certainly true that after a long period of close attention there is an irresistible impulse to stretch, yawn, and ventilate the lungs with deep breaths. If the habitual bodily attitudes which we assume during long periods of mental work are calculated to cause under-ventilation of the lungs, then the respiratory calorimetry methods of measuring energy expenditure will be bound to give fallacious results, for they presuppose normal breathing.

Why is it that many people find they can think better when they are pacing up and down, or walking, or standing up? Is it possibly because their breathing is deeper and their

lung ventilation better? We have it on the authority of Hazlitt that Coleridge preferred to compose his poems while scrambling over plowed fields, and Wordsworth chose to pace up and down a gravel path. Poincaré, the mathematician, derived some of his most intricate formulas spontaneously while walking. Part of this can be accounted for by the increased muscular tension involved, which raises the vigilance of the brain. But at least part of the stimulating effect is probably a function of the increased ventilation of the nervous system.

Estimating Our Own Organic Fatigue

How can we estimate our own organic fatigue? Without any special apparatus, anyone can judge whether he is overtaxing his nervous system by attending to the sensations of tenseness in his body muscles. Cramped feelings in neck and shoulders, ache or twitching in facial muscles, excessive tightness in body and limbs—these are the rough indices of nervous strain and need of rest. Aching and twitching eye muscles, inability to concentrate attention—such things tell us as much that we need to know about the state of our organism as the most elaborate research instruments. In a sense, they tell us more, because they indicate specific fatigue effects in specific mechanisms. They help to localize fatigue in various parts of the sensory-neuromuscular system, whereas the physiological methods can only lump these together into a total effect. This misses the practical point. If a person succumbs to the strain of mental effort, it is not because of total energy expenditure but because of excessive wear on this or that delicate part. The apparent well-being of the organism as a whole causes us to overlook the exhausted state of the obscure process that is nevertheless an indispensable link in the chain. To revert to our earlier analogy of an automobile,

when the car suddenly refuses to go we look for something big to be wrong with it and are slightly chagrined to find that it is only a burned-out wire or a bit of carbon coating on a contact point. A car with nothing more wrong than this can behave as if bewitched. When human nervous mechanisms break down, they may have an equally obscure complaint.

Summary

The second part of this chapter was concerned with the organic method of studying mental fatigue. Some of the methods, such as measurement of pulse rate and breathing, are practical provided it is recognized that if such measurements are to tell anything about the effects of mental effort, they must start from an absolutely resting state. Measurements of muscular tension and skin resistance changes are also practical and give definite results. The net result of investigations of this general type is to show that mental work causes a small but significant increase in metabolism.

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Chapter V

THE SUBJECTIVE ASPECTS OF FATIGUE

We now come to the method of approach which is most important of all from the point of view of the mental worker himself, that is, his own subjective feelings. There should be a continued satisfaction in work. For most of us the working hours fill the greater portion of our waking life. Our attitude toward our job and toward the whole situation in which we carry it on is bound to set the feeling-tone of our entire existence. The recreation hours sandwiched in between sleep and work, important as they are, can never be more than brief interludes. It is not to be expected that work can be continuously interesting or that it can even avoid being distasteful at times. But satisfaction is a more all-pervasive state than this. It is the long-time outlook, the general state of morale that makes the difference between facing the future with confidence or with dread. Satisfaction in work is based on a number of different factors, some of which will be taken up in later chapters. Our present concern is with the relationship between fatigue and the worker's subjective feeling-tone; how subjective fatigue shows itself; how it can be measured accurately; how it is related to work efficiency.

A person may maintain a high level of output and show no evidence of a detrimental organic change, and yet be inefficient in an entirely different way. C. S. Myers (6), an English industrial psychologist, declared on the basis of wide experience that "it is the attitude which finally breaks down in mental work." When high production levels result in an accumulation of feelings of inadequacy, staleness, disgust with the task—in short, a decrease in morale—any temporary

gain is more than offset by the long-time effects. This is a field in which the psychologist is supreme, because he has ways of studying subjective feelings which are distinctly psychological and not used by any other science. He is skilled in securing and analyzing introspective reports. Within limits, these reports can be quantified and standardized and their validity can be tested, so that they are comparable to objective data. But more important still is the fact that the psychologist is getting next to the individual as an individual in a way in which objective approaches fail completely. In this chapter we shall set aside our metaphor of the thinking machine and consider the directive controlling factor, if you will, the driver behind the steering wheel. In doing so, there is no suggestion that we have abandoned our natural science point of view or become dualists and created a "little man within." Rather, we have merely shifted from a discussion of the mechanics to an analysis of the dynamics of mental effort.

How Does Mental Fatigue Feel?

There is some confusion in people's minds about how mental fatigue feels, because their early familiarity with the feelings accompanying physical exhaustion leads them to expect a similar set of subjective symptoms to accompany mental tiredness. When they fail to find these, they conclude that it is not real fatigue. But why should we expect to experience the same types of feelings when entirely different mechanisms suffer wear and tear? Physical fatigue consists of aches and soreness in the large muscles, accompanied by a feeling of impotence, increased awareness of the body's weight, and a strong desire to sit or lie down. The excitability of the sense organs is lessened, and sensations of tonus are reduced because of the relaxed state of the muscles. Thoughts

come rather sluggishly, and only by a special effort, rather than protruding upon the mind unbidden. Associations are restricted in range. Usually relaxation is easy and sleep comes quickly.

Contrast with this the experiences that accompany overtired nerves and brain resulting from mental labor. The large muscles do not ache, although they may feel cramped because of having undergone too little rather than too much use. But the small muscles of the face, eyes, neck, and throat may ache or feel sore, because they have been in a state of exaggerated tenseness. There is a restlessness of the whole body, the result of enforced restraint and of impulses to action that are unsatisfied. Sitting down or lying down only aggravates it. If we try to sleep, thoughts keep crowding our consciousness, the anxious or annoying kinds of thoughts that increase our tenseness and keep us turning and tossing. The sense organs are not deadened as they are in physical exhaustion; they are more excitable than normally. Noises that ordinarily go unnoticed seem intolerable. Emotional irritability is enhanced; the temper is short. There is a sense of impotence, but not for physical exertion. It is rather an unwillingness to attempt any mental work or face any responsibilities. Molehills of decision become mountains. Anyone who considered the contrast between these symptoms and those of physical fatigue would never confuse the two. It is surprising that a school of psychiatrists, not so many years ago, should have so misinterpreted the mental state of neurasthenics (i.e., brain-fagged persons) as to prescribe prolonged physical rest for them, keep them lying in bed, and give them a diet heavy in fats in addition. Perhaps the confusion arose because of the statements of the patients themselves that they felt physically impotent. Psychiatrists today discount this aspect and see that neurasthenics have plenty of physical exercise and recreational activity.

Unfortunately there is a tendency among psychologists to look upon boredom, or "psychic satiation" and loss of motive, as something to be contrasted with true mental fatigue, as a sort of pseudo-fatigue. If such a state affects output adversely, the effect is said to be due to unwillingness on the worker's part rather than inability to work. The individual is said to be inadequately motivated. But why has the motive which he had at first lost its effectiveness? In many cases it is because his capacity to respond to it has been changed by his altered nervous state. It now takes a stronger intensity of the motive to excite the same response. Dodge (2) called this "relative fatigue," because an increase or change in the motive could overcome it. But, as we shall have frequent occasion to point out, a change in motive can overcome physical exhaustion, yet no one argues for this reason that the physical exhaustion is unreal. Dodge never meant to imply that relative fatigue was unreal or had no physical basis.

Quantitative Measures of Feeling-Tone

Many of the problems regarding subjective fatigue that must be solved require that feelings be reduced to a quantitative scale so that they can be compared with output and organic state. It becomes necessary to be able to state a person's feeling-tone in terms of degrees so that a curve can be plotted showing rise and decline with continuous work. We wish to answer such questions as the following:

Does feeling-tone affect output directly, and how closely do the two vary concomitantly?

Are bodily changes immediately reflected in feeling-tone changes? And can there be alterations in feeling-tone with no corresponding bodily changes?

How does feeling-tone respond to rest, changed work, diet, the state of the weather, and a host of other conditions?

There are a number of pitfalls in the measurement of subjective states which we ought to know about and be warned against. Otherwise such data are worthless. One of the most important of these pitfalls is the unreliability of verbal reports or judgments on their conscious experiences made by persons who are not trained introspectors. To do this successfully requires adopting a novel point of view, that of closely examining sensations from obscure parts of the body, sensations that are ordinarily ignored until they become severe. It requires putting into exact quantitative terms what is ordinarily referred to only by the loosest descriptive words like "fresh," "peppy," "tired," "bored," "done in," "fed up," and the like. It requires being scrupulously exact about something that never before seemed important to anyone but ourselves, and about which we were slightly ashamed to talk because of the fear of being classed as hypochondriacs. Some people tend greatly to overrate their feelings of subjective distress, while others just as habitually underrate them. This makes it difficult to compare the feeling-tone curves of different persons, or to lump together data from several individuals into a group curve. This would not be too serious a handicap if we could be sure that a particular individual is always consistent in rating himself. For example, if he has described his feelings at 10 A.M. on Monday as "fair," can we be sure that he means the same thing on Thursday at 3:30 P.M. if at that time he also uses the term "fair"? There seem to be no absolute standards to go by in this field. Thanks to the careful work in psychophysics and in attitude measurement, however, ways have been devised for removing most of the loopholes in rating scales.

A Rating Scale for Feeling-Tone.—The first step in making a rating scale for feeling-tone is to anchor the scale to some fairly stable value and at the same time make the whole range of degrees of feeling-tone large enough to express any

change that is likely to occur. The top extreme can be expressed as "the greatest eagerness for work you ever experienced," and the lowest can be "the most mentally tired" or "the greatest aversion or disgust toward continuing or beginning work." Between these, there will be a degree representing "just average" or "habitual level of feeling toward work." With these three points as anchors, the other degrees can be interpolated to complete the scale. Since the extremes are unlikely to be used as anything but theoretical reference points (because workers rarely reach such extreme degrees of feeling in actual practice), the actual scale can consist of as many points above and below the midpoint as there are clearly distinguishable grades of feeling. Experience shows that there are not more than two or three each above and below. This gives a working scale of either five or seven degrees. Arai (1), whose study of mental fatigue based on herself and on her sixteen subjects has been described, used a three-degree scale, the steps being "good," "medium," and "tired." But this gives hardly enough values to use in making correlations between feeling-changes and output changes during a work session. The relationships she found might have been more significant if her scale had been more flexible. Thorndike (8), on the other hand, went to the opposite extreme; he used ten degrees in his study of the correlation between changes in satisfyingness and output during two hours' work at grading compositions. Satisfyingness was scored every twenty minutes from zero to 10; zero stood for the greatest discomfort or aversion ever experienced, 5 meant average, and 10 represented the greatest satisfaction with work ever experienced. The actual work curve for the two hours shows a drop from 4.4 to 2.6, which utilizes only a small range of the scale. Perhaps a scale with fewer degrees would have been less clumsy and more usable for the subjects. The upper half seems to have been largely superfluous. Even

so, Thorndike was able to show that, whereas speed and accuracy of work remained fairly constant, the satisfyingness to the workers themselves fell off nearly half.

Muscio (5) a few years later correlated the output and feeling-tone curves of a group of twenty women medical students engaged in their regular academic work from 10 A.M. to 5 P.M. They were given three tests every hour in which they did mental work, and an introspective report was taken of their feelings on a four-point scale: "fit," "fairly fit," "a little tired," "very tired." A similar group of values were obtained from fifteen young women typists. The resulting curves show a rapid deterioration in feeling-tone, but the correlation with output curves is very slight, except in the general trend. The disadvantages of Muscio's scale are lack of a stable point to which it is anchored, and the absence of enough degrees for sensitive measurement.

An entirely different type of scale was used by Poffenberger (7) in his study of the decrement that developed in four different tasks of varying homogeneity: doing additions, completing sentences, taking intelligence tests, and judging compositions. Seven degrees of feeling-tone were recorded, from "extremely good" to "extremely tired." But it was the way in which he derived his zero point that was unique. Instead of attempting to anchor it to a permanent or all-time value, he arbitrarily called the initial feeling-level of the day "zero" and then assigned plus values to all changes toward more unpleasant, and minus values to all changes in the direction of more pleasant. This tends to have two effects; it would make the scale depend on a point which varies from day to day, that is, the initial level of each day's work period, and hence would preclude any day-to-day comparisons. And it would put the zero point in the middle of the scale instead of at the bottom as Thorndike placed his. Both these results can be justified on the ground that we are interested in rela-

tive rather than absolute changes. We do, in fact, treat the initial level in work curves as an arbitrary 100 per cent value in computing decrements in output. Poffenberger's method also makes comparisons between individuals more feasible

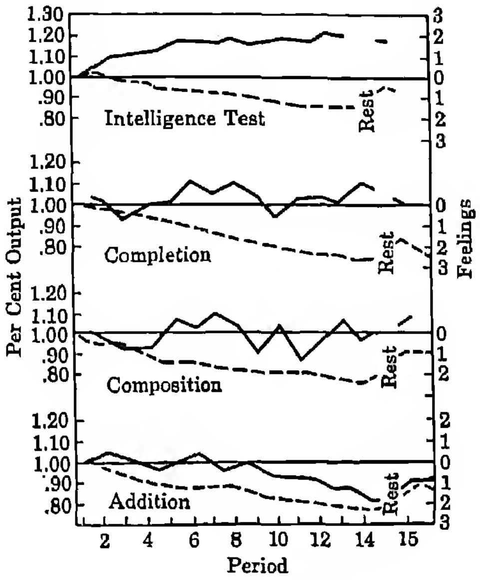

Fig. 7.—Relation between output and feelings in four forms of mental work. Solid lines represent output, and dotted lines represent feeling-tone. (From A. T. Poffenberger, Effects of continuous work upon output and feelings, *J. Appl. Psychol.*, 1928, 12, 459–467.)

by avoiding wide discrepancies in the starting point. He called for introspective judgments of feeling-tone at the end of each twenty-one-minute period during five and one-half hours of work. Certainly more frequent interruptions would have seriously disrupted performance patterns and might have invalidated the whole study.

Relation of Feeling-Tone Decrement to Kind of Task.—Poffenberger computed output records and plotted work

curves of both feelings and output, so that a comparison could be made between the general direction of the two. The results, which are presented in Fig. 7, show that feelings dropped right from the start, and much more rapidly than speed or accuracy. In the intelligence tests there was an improvement of 20 per cent in output, and a drop of 1.3 steps in feeling; addition gave a loss of 20 per cent in output and 2.1 steps in feeling. From this Poffenberger drew the general conclusion that there is no positive relation between changes in level of output and changes in feeling-tone. He points out, however, that among individual workers, those who had the greatest output loss suffered the greatest decrement in feeling-tone.

How do Poffenberger's feeling-tone curves for the various jobs compare with the objective decrements in those jobs? We find that addition, which gave the greatest output decrement of all, also showed the largest drop in feeling-tone, 2.1 steps. Intelligence tests, which gave the least decrement, or rather gave an increment in level of performance, also showed the least feeling-tone drop, 1.3 steps. Subjective feelings, then, can be said to corroborate what output decrement records tell us, i.e., that the more homogeneous the type of mental work, the less the thinking machine is able to tolerate it for any continuous period of time. This conclusion is based on the fact that addition is extremely homogeneous whereas intelligence tests involve a great deal of variety.

Feeling-Tone as Affected by Output.—We have seen that feelings deteriorate rather rapidly in most continuous work. The curve seems not to show any preliminary rise corresponding to warming-up, but to drop consistently from the beginning. Output is remarkably free from the effect of this drop in feelings until it reaches an extreme degree. But what of the reverse relation? Does the level of productivity react upon the worker's attitude and change it? Yes, decidedly, if

the worker is aware of how well or how poorly he is performing. Successful performance raises the feeling-tone; failure depresses it. But the influence of success and failure on the future performance level is quite different. Every worker is under the control of an ideal or standard which he sets for himself, more or less unconsciously. When he finds himself falling below this standard he spontaneously reacts with increased effort. This may explain in part the discrepancy which exists between feelings and output. The worker's subconscious standard operates to maintain a certain level regardless of a decided lowering of the degree of satisfaction which he is deriving from the performance.

Cycles of Feeling-Tone

It is risky to try to compare absolute amounts of drop in feeling-level during work periods at different times of day or on different days. This is because of the cycles of feeling-tone. Not only are there chance variations from day to day, but Hersey (4) reports that there are cyclical fluctuations in feeling-tone, some of them taking place within a single day, others within the week, and still longer cycles having an average period of three to nine weeks, varying from individual to individual. These cycles encompass a range of feeling all the way from elation to depression, and a certain tendency for productivity to vary in a comparable way. They seem to be dictated to a certain degree by the physical state of the worker. At any rate, their existence suggests the need for caution in assuming that decrements and increments in feeling-level during a prolonged work period are products of the work itself. Another precaution is necessary in the interpretation of the amount of drop in degrees on a given scale. Suppose a person reports an initial level of "extremely good" on one day and, during two hours of work, drops to the

level of "good." On another day, being in the depressed phase of the cycle, he reports an initial level of "rather tired" and drops to "very tired" after two hours' work. Can we assume that, because each of these is a drop of one step on the scale, they represent equal decrements? Elation is confident, vigorous, masterful over difficulties. Depression is pessimistic, timid, weak. The steps at the lower end of the scale are probably much nearer together than those at the top.

More will be said about the feeling-tone cycles in Chapter XIII, in connection with weekly and seasonal variations in productivity. Without doubt, they have an organic basis, but they depend also on such variable factors as the amount of sleep and rest that we obtain, the changes in motivation toward our job, and the moods imparted by weather conditions and by innumerable suggestions received from our physical surroundings. The topics treated in Chapters VII to XII all have an important bearing on the problem of maintaining a high level of feeling-tone.

Does Lowered Feeling-Tone Affect Later Performance?

Effect on Recovery Rate.—Several of Kraepelin's students have called attention to the influence of the subject's attitude during work and rest on the rate of recuperation from fatigue. For example, one of them, Graf (3), found that the time necessary for recovery after a given amount of work was more a function of the worker's state of mind during the work period than of the length of time he actually worked. The amount of attentional strain and volitional effort put into the task were also important. If a worker anticipated that he would become greatly fatigued, he actually needed a longer rest to raise his affective-tone sufficiently to resume work. Can we not conclude from all this that feelings are a better index of the probable long-time efficiency and organic

welfare of an individual than the objective decrement shown in his work curve?

How Specific Is Feeling-Tone Decrement?—There is a distinction here that needs to be made. The bases of boredom, disgust, or lowered affective-tone can be very specific or local. They can indicate a relatively restricted locus of the organic counterparts. This is proved by the fact that a different kind of work may immediately become interesting to the fatigued mental worker, even without any rest, but a return to the initial task is impossible without a recovery period, unless he puts forth an inordinate amount of voluntary effort of attention. And if he forces himself, worry and anxiety result. Myers (6) believes that this is the reason for the connection between mental fatigue and psychasthenia, a neurosis which is much more common among mental than among physical workers. He says that in these cases, "conflicting ideas, hitherto repressed because of their incompatible or undesirable emotional concomitants, break loose from inhibition, causing anxious moods, disorderly unreasoned fears, and the like, to intrude into consciousness." It is obvious that the remedy for this type of subjective staleness is a change of task or a change of work situation, for the situation in which we carry on continuous mental work can be the factor whose sameness and monotony create the acute boredom just as much as the homogeneity of the task itself.

This problem of whether we can develop specific feeling-tone decrements toward particular tasks is one aspect of a much broader problem. Are there two distinct types of fatigue, general fatigue and specific fatigue? This question is so important that the following chapter is given over to it.

Summary

The general conclusion from experimental work on the relation between immediate productivity and subjective

feelings is that there is a rather low correlation between them. Output can rise temporarily while feelings are deteriorating. But it would be folly to conclude from this that the worker's feelings can be safely ignored. On the contrary, there is every reason to suppose that they are much more sensitive indicators of the actual or potential future organic condition than any other measure we have described thus far. If a monotonous task generates feelings of intense boredom or disgust, this can be taken as a warning on the part of the biologically protective function of the nervous system that further continuation of that task, at least under the same conditions, is hazardous.

The methods described in the present chapter for measuring feelings of satisfaction and dissatisfaction are by no means exhaustive. A good review of recent methods is to be found in the article on Morale by I. L. Child, in the *Psychological Bulletin* for 1941. Among these, the printed questionnaire has been used successfully by Likert, and by Rundquist and Sletto. A number of questions are asked about the testee's attitudes, and from his answers an estimate is made of his morale. The personal interview has been found especially helpful by a number of psychologists, notably Roethlisberger and Dickson. They also used an observational method in which an observer studied the behavior, expressed feelings, and the like, of the workers in a certain industrial situation over a long period. These methods are, of course, particularly designed for industrial managers. The list of supplementary readings below includes references to these and similar studies.

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Chapter VI

GENERAL AND SPECIFIC FATIGUE

There are two quite different kinds of physical tiredness. We may become tired all over, the whole body experiencing exhaustion; this occurs when we have engaged in some physical activity that exercises a wide range of muscles, such as a vigorous sport. On the other hand, we may develop fatigue in a very limited group of muscles while the rest of the body has been resting; this often occurs in industrial work, in jobs that involve doing a single operation over and over. In the first case, recovery calls for complete rest of the entire body. In the second, only the particular group of muscles that was involved in the operation needs time to recuperate. Often this can be accomplished by shifting to a different activity that calls for entirely different muscle patterns. Of course, the picture is never quite as simple as this, for the acute fatigue of the limited muscle group is accompanied by a mild amount of general weariness. But the distinction holds in principle.

Can the same distinction be applied to fatigue from mental work? We have already had a number of occasions for raising the question as to whether mental fatigue is general, applying to the whole brain, or confined to a very few mechanisms which have been overexercised in the performance of a particular task. One of these occasions was the discussion of the interpolated task method of measuring objective decrement. That is, can we measure the amount of fatigue a person has suffered from continuous work on mental arithmetic by testing his reaction time to a flash of light, or finding how many pounds pressure he can exert on a dynamom-

eter, or how fast he can memorize a list of words? At the time this question was asked, our answer was that these indirect methods of measuring objective decrement had proved worthless because the fatigue is specific to the nervous elements directly involved in the task. Another occasion for discussing the question was in connection with Painter's and Arai's work curves. Painter (**10**), it will be recalled, worked on mental multiplication for three hours and a half, and at the end of that time, when this task became impossible, tried other kinds of mental work and found them equally impossible. In fact, the small amount of mental effort necessary to undress for bed was more than his tired brain could face. This certainly looks like a very general condition of nervous exhaustion. But Arai (**1**) also tried both herself and her subjects on other types of mental tasks at the end of one of her long periods of mental multiplication. She found that after nine and one-half hours of work she required 21.4 per cent longer to memorize a list of words than she did before. This compares with an increase of approximately 100 per cent in the time required to do one multiplication example. We might say that only about one-fourth of the fatigue developed in the multiplication task carried over to the memorizing activity. If she had used her memorizing ability as a measure of fatigue from mental arithmetic, she would have underestimated it ridiculously. On the other hand, her subjects, who showed an average decrement of 24 per cent after two hours' work on multiplication, had a 13.5 per cent decrement in ability to memorize syllables. This amounts to a transfer of about half the decrement from one task to the other. Addition and free association, however, showed no such transfer. These activities were practically unaffected.

It is from these apparently confusing and contradictory results that we must develop principles which will explain the facts. This leads first of all to the concept of more than

one type of mental fatigue. Possibly there are two main types, a general and a specific variety; possibly there are also others.

The Difference Between General and Specific Fatigue

In the last few years there have been two tendencies of thought on the way the brain functions in behavior. One stresses the action of particular parts, pathways, centers, or restricted areas. This point of view results from the emphasis on *reflex arcs* as the units of nervous function even in the case of the higher thinking processes, not just in the case of simpler levels of performance. This is the point of view of behaviorism; it was borrowed from physiology. According to this theory, it would be possible to fatigue a relatively limited sensory-neuromuscular pattern without greatly affecting other patterns or regions. But this theory is disputed by all the evidence from direct studies of the brain made by Lashley (8) and others that the nervous system always functions as a unit. Lashley's work indicates that any activity in any region within the highest centers involves the cooperation of practically every other part. This is called the principle of mass action. The truth seems to lie between these two extreme views. We can answer the question only by citing experiments on very simple repetitive tasks, where large decrements developed without carrying over in any degree to other tasks. We might say that the tendency is for the fatigue to be just as specific as the task is homogeneous. Some types of work involve many different mental operations, so that no one of them is excessively used. Others involve doing the same operation repeatedly. A good example of the first is supervising a whole department. The second can be illustrated by an accountant's work.

One way in which general fatigue might appear, then, is

in performing very complex or varied mental tasks. But there are other processes that enter into almost any type of task, in addition to the operations of the job itself. One of these is the maintenance of a general overall controlling set. This is the set which holds our attention to the work, represses all tendencies to respond to irrelevant things, and regulates the excitation level of the brain, keeping it at an optimal degree for efficient work. This set is general enough so that, if it were fatigued in connection with a particular task, ability to attend to any other task would also be affected. An interesting illustration of the action of one of these general attentive sets is this: If a person is attending closely to one thing, it may reinforce his perception of other things which are not directly concerned with it. For example, a certain psychologist who was investigating the ability to hear and react to very weak sounds found that his subjects could hear them better and react more correctly if they were asked to do mental multiplication at the same time. That is, the attentive set is so general in its operation that it spreads from one activity to another entirely different one. Of course there are plenty of exceptions to this. If you are absorbed in reading a book, you may fail to hear someone speak your name. In this case, the set is to suppress actively any stimuli that might interrupt the task in hand. This is the kind of exception that proves the rule.

The Reservoir Theory of Mental Operation.—Some theorists have likened the way in which the brain functions in behavior to a reservoir. A number of streams of water can be drawn from a single reservoir, but the more that is drawn off in one direction the smaller will be the flow in other directions. These theorists hold that we have a sort of mental energy reservoir from which energy can be directed to any particular activity, but only at the cost of depleting the supply in the reservoir. According to this, general mental fatigue

would be the condition caused by depleting the reservoir, whether this resulted from drawing off the energy in a single direction continuously or from drawing off smaller amounts in several different directions at the same time. The illustration in the preceding paragraph does not fit such a theory, for it shows that one activity can actually reinforce another if both can be brought under one general attentive set. And if the general set breaks down, both activities are equally affected. An illustration can be found on the level of simple tests of motor strength. The strength with which a person can squeeze a dynamometer is partly a matter of his sheer determination to make a good record. If he squeezes one dynamometer with his right hand and another with his left at the same moment, the strength of the squeeze in each hand will be found to be greater than if he were squeezing only one dynamometer at a time. The two reinforce each other. It is only when two activities are antagonistic to each other that they exert a mutually weakening effect. Hence the reservoir theory is of doubtful value in accounting for general fatigue. There is only one sense in which it can hold true. In the long run, any overexertion, mental or physical, gradually consumes the vital reserves and results in a general state of physiological fatigue. At such a time the system is a prey to all kinds of infections. Recovery from a general run-down state must proceed along the lines of rebuilding the body's vital reserves.

We can look upon mental fatigue, then, as being a combination of the following components:

1. Specific fatigue, which is the depletion of the particular mechanisms called into operation by the task itself, plus those supporting processes of tension and reinforcement that accompany them. It is very particular, and is likely to affect only subsequent mental tasks in which these same operations are involved.

2. General fatigue, of the type in which the mental work engaged in is so complex or varied in the operations called for that a great many mental functions are depleted. In this case, all the specific fatigue conditions combine to produce a widespread or general fatigue.

3. General fatigue, of the type that results when the main attentive and controlling work set becomes tired out. It can carry over to almost any subsequent mental task because all tasks require controlled attention.

4. General debility, a much rarer condition of the depletion of the body's vital reserves, which can result from mental exertion lasting for days or weeks without adequate rest.

Transfer of Fatigue

We are now in a position to answer a practical question. To what degree can we expect fatigue developed in one kind of work to transfer to other kinds of work which we do immediately afterward? Can a tired mental worker obtain any relief by changing to a somewhat different task? We can reply that if his general work set has suffered a decrement so that he no longer feels a zest for anything that requires continuous attention, this decrement will transfer to any task he undertakes later. But if it is only the operations in the particular job that have suffered a decrement, and if he changes to a type of work so different that it does not call any of the fatigued processes into use, the amount of decrement transferred should be negligible. Perhaps the assumption that any two jobs are so different that they do not involve any of the same operations is false. There seems to be little in common, for instance, between such activities as adding figures and canceling letters, but Chapman (5) found that alternation between them from time to time gave only half the recovery that followed alternate rest and work. And

another investigator found that the benefit derived from fifteen minutes of complete rest in the middle of a two-hour session in addition was considerably more than twice that derived from mild mental recreation.

The Principle of Similarity.—When we compare the kinds of mental work which show the largest amount of transfer between them with those which show the least, we cannot escape the conclusion that it is the factor of degree of similarity that counts. This can mean similarity of various sorts. Two tasks can be similar because they involve some of the same manipulations, as in multiplying and dividing, or because they deal with similar subject matter, like listening to war news on the radio after reading it in the newspaper. It has been shown that there is a direct proportionality between the number of identical features in any two tasks and the amount of decrement that will transfer from one of them to the other (2). The identical feature can be such a simple thing as an identical posture. For example, it has been found that a person can overcome considerable fatigue by merely changing his posture, the way he sits at a desk, or by getting up and sitting down again in a slightly different position. This is even truer in the case of work that calls for the maintenance of a tense attitude or cramped posture or for movements of a restricted muscle group, as in writing longhand or typewriting. Finally, we should recognize that all work is carried on in a total setting which may remain unchanged even though the work is changed to a totally dissimilar type. Much of the benefit of the new task may be lost if the setting remains unaltered, provided, of course, that the monotony of the surroundings was responsible for the bored or restless feelings in the first place. A certain psychiatrist has described what he calls the "tired housewife's neurosis" which he claims affects women who are compelled to do their housework in isolation from human contacts all day long, even

though the work itself is not strenuous. It is nothing more or less than a state of acute boredom resulting from the sameness of the setting and the lack of the kind of relief which those who work in social situations secure from conversation with their fellows, exchange of ideas, and the like. It must be the sameness of the setting which furnishes the monotonous element in housework, for the operations themselves are varied enough, considerably more so, in fact, than those in many office and industrial routine jobs. One of the chief factors people mention as contributing to the satisfaction of a day's work is their stimulating contacts with other persons. It is this lack that constitutes the monotonous feature in the isolated housewife's life.

The beneficial effect of a change of task on the work curve cannot be exaggerated. It has been proved repeatedly that one or two changes of task during the morning and afternoon of a workday can yield almost as much benefit as rests, if the new task is different enough. In the industrial situation referred to on page 64, Miles and Skilbeck, by introducing a fifteen-minute period of change of work twice a day, increased the output of one group of workers 14 per cent. Wyatt (14) obtained an increase of 7 to 12 per cent in the productivity of another group by letting them work at a different job during the latter half of the morning and afternoon.

Transfer of Set

Among the factors which carry over from one task to another and influence the subsequent performance level are particular sets or work attitudes which are not as general as the attentive set previously discussed but are more general than the specific operations of the given job. These include accuracy sets, speed sets, and rhythm sets. Brentlinger found, in an unpublished study, that if a person is first given a task

which calls for a high degree of accuracy, this will carry over to a subsequent task and improve his accuracy in it; whereas if the first task emphasizes speed, this will be the factor which will be carried over to the second. This happens unconsciously. Even particular work rhythms persist. Cathcart and Dawson (4) set up an experiment to determine the amount of transfer of such rhythms. For example, if a subject naturally makes a certain response at a given rhythm, then is given another response to be made at a faster or slower rate, and then returns to the original response, will he be influenced unconsciously in his subsequent rhythm of work by the intervening tempo? Will this new rate be deflected in the direction of the intervening rate? These two investigators used all sorts of performances, from as simple an act as tapping to as complex an act as playing on the piano. In every case, they found that the interpolated rate persisted and pulled the subsequent rate or tempo in its direction. One subject's results for the tapping test are shown in the accompanying table.

NUMBER OF TAPS MADE IN FIVE SECONDS

Initial Rate	Intervening Rate	Final Rate
11	23 (faster)	15
12	7 (slower)	10

Skilled musicians were affected in a similar way, even when playing familiar music whose correct tempo they were well aware of. If a composition requiring a slow tempo was followed by one calling for a rapid tempo, the performer would subsequently play the originally slow music at a more rapid rate, and vice versa. We have here a clear indication that such "rate sets" carry over, and that if a worker became

fatigued in one task and slowed down, this lower tempo could carry over to a subsequent task and appear in it as a transferred decrement. Sharp (11) demonstrated how this takes place when he showed that these work sets are transferred in the form of residual tensions in the muscles. This ties them in with the group of phenomena discussed in Chapter II.

We must not overlook the fact that a direct reverse effect can be and often is produced. For example, Frank (7) found that if the level of performance attained in the first period was well below the ideal rate which the subject had adopted and he was aware of this fact, in the second task his ideal would be raised in compensation and he would perform at a higher level than otherwise.

Fatigue Transfer Between Mental and Physical Work

The question is often raised as to the effect of a physically fatigued state on mental performance. This was put to a systematic test some years ago by Dockeray (6). He produced physical fatigue in his subjects by giving them gymnastic exercises, such as track running, that involve the musculature of the whole body, and calisthenics for the isolated exercise of particular muscle groups. This method of producing fatigue might be criticized on the ground that it would result in a rapid superficial exhaustion which, because it has accumulated so rapidly, is not exactly comparable with the fatigue from a day's work. But the mental work was given immediately afterward and should show any effects that were present. Four types of mental work were used: an addition test, a multiplication test, a simple attention task consisting of listening and reacting to a sounder, and an association task involving memorizing ten pairs of syllables. Dokeray's results are not consistent. In two of the tasks, addi-

tion and multiplication, the results were very irregular. A subject might do better after the physical exercise than after a rest period, or his speed might increase and his accuracy decrease. The results also depended on the amount of physical work done. One subject made a poor record after rest, improved after running 18 laps, and made still greater improvement after 27 and 36 laps. It looks as though speed of reaction in operations involving well-perfected habits like adding numbers is facilitated by the added nervous excitement created by track running. Even in this task, however, accuracy was detrimentally affected, because excessive nervous excitement interferes with fine coordination. Furthermore, in the other mental tasks where speed was not a factor, i.e., in attending to the sound of the buzzer and in memorizing syllables, the results were consistently in one direction, showing a diminished efficiency. A different study, made some time later by Whiteley (12), is closely enough related to Dockeray's to warrant mention at this point. Whiteley gave his subjects vigorous calisthenic exercises for a period of five minutes. Immediately afterward they were given lists of three- and four-letter words to memorize. Neither the rate nor the quality of the learning process seemed to be affected. We must question seriously whether any very pronounced degree of fatigue was reached in so short a workout, but the absence of any beneficial effect from the physical exertion supports Dockeray's earlier results in regard to memory.

We are forced to the conclusion that small amounts of physical fatigue have no marked effects on mental efficiency, but that greater amounts may have some effect in reducing precision of response, in dulling sense perception slightly, and possibly in retarding the formation of new associations. But these results are slight indeed compared with the fatigue decrement which would be transferred to these mental tasks

if they were preceded by mental instead of physical activity. The main argument for assuming that any after-effects of physical activity would be likely to carry over to mental work is the known fact that the fatigue products of physical exertion are spread throughout the whole organism by the blood stream. This takes place in a fairly short time, but in the light of Dockeray's and Whiteley's data the effects are negligible. The set for doing physical work is entirely different from the set for doing mental work, so that it is a real relief to shift from the former to the latter.

What of the reverse process, shifting from mental to physi-

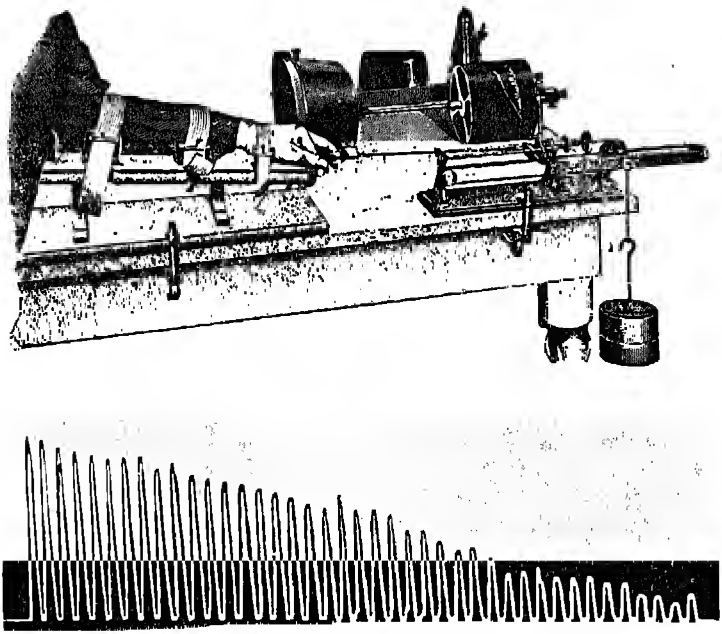

Fig. 8.—Above is a picture of a Mosso ergograph (Courtesy of C. H. Stoelting Co.). Below is a typical ergogram (from A. G. Bills, *General Experimental Psychology*, Longmans, Green, 1934).

cal work? If a person has reached a high degree of mental fatigue, will this transfer to a subsequent physical task and interfere with his performance of it? All the evidence that has accumulated seems to point to a negative answer, with the exception of one early study, but this one study has been so widely read and quoted that a false impression has been created. We refer to the personal experience that Mosso (9) reported in his treatise on fatigue which has been a classic for many years. The experiment is of very doubtful interpretation. He reported that after a period of the most strenuous mental effort such as was involved in giving a lecture before one of his classes or in taking a two-hour examination, both he and his friend, Dr. Maggio, observed a decided change in the ergograms of their finger muscles. Ergograms, it will be recalled, are work records for restricted muscle groups. Fig. 8 shows an ergograph. The subject's arm is strapped down tight, and he pulls against the suspended weight with his finger, once each second, until exhausted. These two investigators found that the total duration was shorter and the height of the individual pulls was reduced. This was true not only of the curve resulting from continuous voluntary contraction of the finger muscles, but also of the record obtained by direct electrical stimulation of the base of the muscle. Mosso admits that he failed to secure the same results from everyone he tested. The most serious criticism of his study is his assumption that delivering a lecture is mainly mental work—it can be a vigorous physical workout for some speakers, especially for an Italian who gestures constantly. This criticism does not of course apply to the two-hour examination. However, in a comparable study, Bolton (3) showed that a two-hour session of adding figures, followed by ergographic work, augmented instead of diminishing his ergogram.

The question has more than theoretical interest, for it is

important to know whether mild physical exercise is likely to have any detrimental effect on the efficiency of mental workers when it is introduced into rest periods or recreational sessions. Wyatt (13) found that a fifteen-minute period of rest between two hours of work in addition gave much better results if the time was spent in complete relaxation than if it was devoted to such mild physical exercise as taking a walk. Relaxation brought an improvement of 9.3 per cent in the second hour after the rest period, whereas the physical exercise yielded only 1.5 per cent improvement. This should warn us against the too ready assumption that physical exercise is always a good way of recuperating from mental fatigue.

The Principles of Fatigue Transfer

We are now in a position to summarize the main conditions under which the decrement developed in one task can be expected to transfer to a second task which is engaged in directly afterward. These conditions are:

When the tasks are both mental or both physical or when both have elements of each.

When the two tasks are quite similar, involving the use of some of the same neuromuscular processes.

When the work set, i.e., the directing and controlling attentive set, is common to both.

When the first task is so complex that it results in the widespread fatigue of many mechanisms.

When the setting in which the work is done remains unchanged, provided this feature was the fatiguing element in the first task.

Supplementary Reading

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Chapter VII

REST AND RECOVERY FROM MENTAL WORK

UP to this point, our main purpose has been to establish the case for mental fatigue. We have shown that it is a very real condition, capable of being measured in several different ways; that it is aggravated by certain factors in the work situation and lessened by others. The first concern of a program of mental work hygiene should be to seek every means of minimizing fatigue and to discover the most effective methods for removing it after it has developed.

Fatigue is a state of lowered efficiency from which recovery can be made by rest. Probably the amount of depletion of energy resulting from normal amounts of daily work, either physical or mental, is no more than can be recovered from by a reasonable program of rest, relaxation, and sleep. What is a reasonable program? This necessarily varies with the individual, and it rests with him to discover by trial and error what his personal demands are in these matters, to insure a maximum of satisfaction with his work. Probably there are exceptional persons who are so responsive to all kinds of stimuli in their environments, especially those associated with their work, that they suffer excessive fatigue from an ordinary day. It is of the greatest importance for such individuals to discover this early and make provision for it. But there are equally extreme cases of persons who are extraordinarily resistant to overstimulation and who can pursue a mental task many hours without feeling any ill effects or showing any marked deterioration in efficiency level. Such supermen will always have to be a law unto themselves. We are here concerned not with either of these extremes but with the

average group of people who wish to know how much mental work they can safely stand at a stretch without rest, and how much and how often they should rest. They also want to know what form the rest should take to be of the greatest benefit—whether it should consist in complete relaxation, mild recreational activities of a social nature, or physical exercise. To give a significant answer to these questions, we must first know something about the course of recovery after physical and mental effort. How is the rate of recovery related to the length and severity of the previous work session? Is the rate rapid at first and then slower as time goes on, or is there a lag in the recuperation rate right after work, and then an acceleration later as the processes of repair get under way? Or can we assume that for each minute spent in rest there will be an equal recovery gain? Finally, how is the recovery rate related to the kind of task we have been working on; do we recuperate from different kinds of work at different rates?

The Curve of Recovery

We cannot safely ignore the question of muscular fatigue and recovery because the muscular element enters most of the work situations in which we are interested. Usually some limited muscle group, like the hands and fingers in writing or typewriting, or the eye muscles which are constantly being strained in close work, or the muscles of the back and shoulders, bears the brunt of the physical fatigue, whereas the rest of the gross body muscles are not brought into play. For this reason, studies which have been made on fatigue in the finger or hand by means of the widely used laboratory instrument, the ergograph, are closest to our interest.

A study by Manzer (4) gives valuable data on the curve of recovery from muscular fatigue in terms of increase in out-

put after increasing amounts of rest. He plotted separate curves for five different muscle groups: the finger, the hand, the arm, the leg, and the trunk. The subject flexed these limbs repeatedly until he reached a state of exhaustion, then rested either five, ten, or twenty minutes, and then was retested to determine the degree of recuperation that had occurred in that time. The average recovery after five minutes was 82 per cent of the original level; after ten minutes it was 90 per cent and after twenty minutes 95 per cent. In other words, at least three-quarters of the energy lost in work had been regained within the first five minutes. After that, the additional units of rest yielded diminishing returns in recuperative value. By comparing his finger and hand curves with those for the larger muscles of leg and trunk, Manzer found that the smaller muscles recover much more rapidly. This seems reasonable when we consider that the amount of waste products is much smaller and can therefore be disposed of more rapidly.

Is there a similar curve of recovery in organic condition, in the case of muscular work? Schubert (6) found that, for periods of muscular exertion lasting up to twenty minutes, the rate of oxygen consumption during the first three minutes of rest following the work was actually greater than it was during work. Thereafter, it gradually fell off to the resting level of the pre-work period. The excess oxygen consumed during the recovery period was a function of the length of the preceding work period. This indicates a peculiar fact about the body metabolism. During work, an oxygen debt accumulates; the longer we work, the greater the debt we incur. It is only after work ceases that the accumulated debt can be paid. The process of recovery, therefore, is a matter of paying this debt, accumulating a reserve to fall back on in the next work session.

One important point in both Schubert's and Manzer's

studies is not fully answered. Is the rate of recovery just proportional to the length of the preceding work period, or do longer work periods demand disproportionately long rest periods? Poffenberger concludes from the available evidence that the energy expenditure per unit of work increases as the work period is lengthened. Therefore more rest is needed to recover from a given unit of work done at the end of a work session than from an equal unit done early in the session. Long work periods without rest are uneconomical because of the disproportionate amount of rest which is ultimately required for recovery from them.

When the length of the rest period is insufficient for complete recovery, there is a gradual accumulation of a residue of fatigue. Manzer found, for example, that a two-minute rest period brought over 60 per cent recovery after one work session. When a second work period of equal length followed the rest, a subsequent rest of two minutes produced less recovery. By the tenth work session, a two-minute rest gave only 40 per cent recovery.

What percentage of the total time, in an eight-hour day of vigorous physical work, should be spent in rest, and how should it be distributed? Shepard (7) had a subject undertake a medium-heavy physical task—pulling against chest weights by walking forward and back—for eight hours, under varying conditions of rest. The length of the rest periods was always eight minutes, but they were introduced at varying frequencies, from a maximum of one every twenty-five minutes to a minimum of one every sixty. The maximum output of work for the day was obtained when the rests were given every forty-five minutes. When energy expenditure was taken into consideration, slightly more frequent rests proved beneficial. Shepard concludes that for young men, 16.6 per cent of the total work day should be spent in rest.

The Recovery Curve for Mental Work

The facts just presented are significant also for mental tasks that involve a muscular element, because they give us some idea of the rate at which we can expect to recover from local muscular fatigue. But in addition we need a picture of the form of the recovery curve for the neural element itself. We need information gained by studying all three methods of approach, the output, the organic state, and the feeling-tone. This information is now available in the results of a research investigation by Kirby (3), which has not yet been published. The data previously reported are somewhat fragmentary. Poffenberger (5) found that ten minutes of rest, after more than five hours of mental work, produced an absolute improvement in the feeling-tone of his subjects which was fairly constant regardless of the type of task or the amount of decrement that had developed during work. But the recovery in feeling-tone bore no relation to the increase in output level resulting from rest. For example, in one of the kinds of mental work, a completion test, there was no improvement in performance after the rest; on the contrary, there was a loss, but there was a marked recovery in feeling-tone. Poffenberger and others made a study of the recovery in organic condition. They report that the pickup, after twenty minutes spent in addition, was rather slow. The metabolic rate seldom returned to the normal level during several minutes of rest, and was frequently higher at that time than it was immediately after work ceased.

In order to secure a clearer picture of all these relationships, Kirby made simultaneous records of the objective output, feeling-tone, and organic state of 150 subjects of college age, before work, during thirty minutes of mental work, and

during rest following work. Organic state was measured by the galvanic skin resistance method described in Chapter IV. Plate 6 shows the apparatus used. Electrodes were fastened to the subject's left hand and arm so that there was no interference with his work. By obtaining parallel records of all three aspects of fatigue, she was able to make a direct comparison of the general course of recovery in each. The mental task used to develop fatigue was the continuous solving of "figure-analogy" problems, a type of material which is used a great deal in intelligence tests. It involves reasoning by analogy and hence is of a little higher order than addition or color naming, but it can be made highly homogeneous. All the problems were of equal difficulty, and the average subject could solve a large number of them during the half hour of work. The objective decrement was measured by recording number of problems solved, number correct, and number of blocks (i.e., enforced pauses or gaps in responding) occurring in successive minutes. All of her subjects worked the same length of time, but one group rested for two minutes after work, another group rested three minutes, another five, another seven, another ten, and another twenty minutes. Each group contained 25 subjects, so the average values for the different lengths of rest were very stable. From these values a five-point curve could be constructed, indicating the level of recovery reached after each of these periods of time. Feeling-tone was measured before and during work, and during the rest period, by means of a scale similar to those described in Chapter V. The organic state was continuously recorded, beginning fifteen minutes before the mental work was started, so as to obtain a basal value under conditions of complete relaxation. It was measured throughout the work period and during the rest period following work. The measurements were expressed in ohms resistance, which rises under conditions of relaxa-

tion and drops during mental effort or attentional strain. In other words, an increase in the expenditure of metabolic

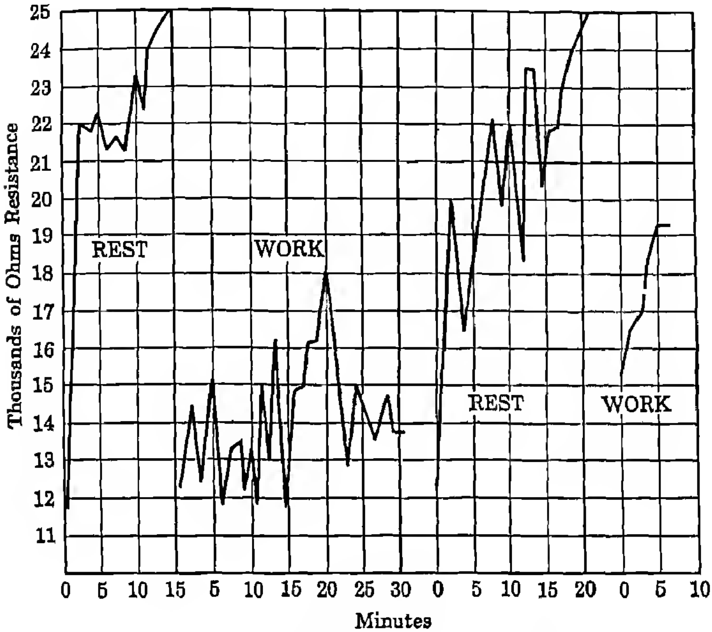

FIG. 9.—Skin resistance changes before and during mental work, and during the recovery period following mental work; record of one subject. (From an unpublished thesis by T. K. Kirby, 1942, in the University of Cincinnati Library.)

energy is indicated by a drop in the skin resistance curve, and a decrease is shown by a rise in the curve. These results are shown in Figs. 9 and 10.

Let us consider first the organic state. During the period of relaxation preceding work, resistance is building up to a high point. As soon as mental work is begun, the resistance drops instantly to a very low point, indicating that the low rate of energy consumption in the preceding period of relaxation

changed instantly to an extremely high rate. This high rate continues, with occasional ups and downs, during the entire work period. As soon as the rest begins after work, the energy consumption rate starts a rapid decline which continues until the end of the rest period. This indicates that recovery from the organic effect of the mental exertion was

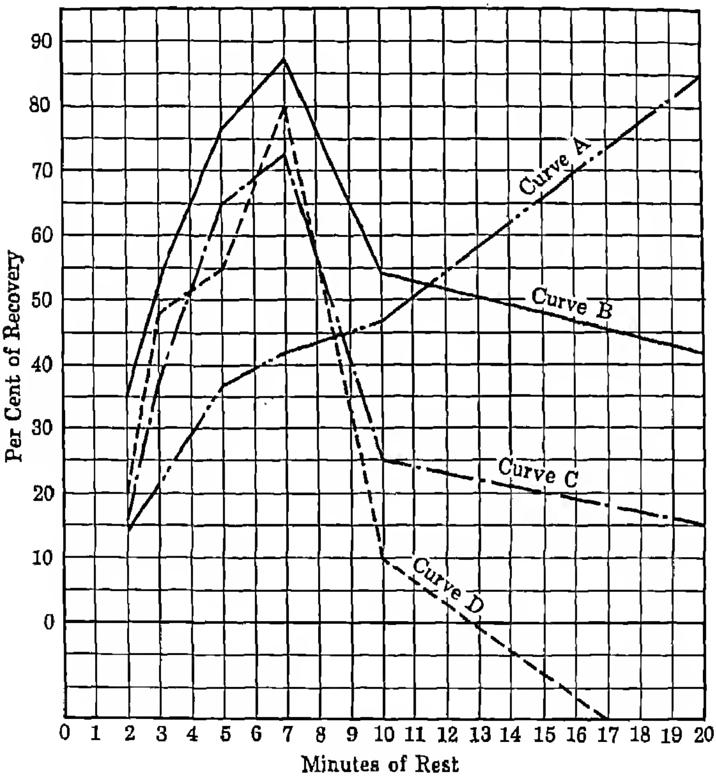

Fig. 10.—Composite recovery curves following mental work. Curve *A* shows skin resistance changes during recovery, Curve *B* shows recovery in ability to work problems correctly, Curve *C* shows recovery from the blocking tendency, and Curve *D* shows the course of feeling-tone during the recovery period. (From *ibid.*)

rapid and continuous but had reached only about 85 per cent of the pre-work level at the end of twenty minutes of rest. There is reason to think, though, that beyond a certain point this was accompanied by mental and probably muscular relaxation that exceeded the optimal amount for efficient resumption of work, and left the subjects unready to resume the task. This can be seen by a comparison of the resistance curve with the output and feeling-tone curves.

Let us turn next to the objective output curves. One shows recovery in speed and accuracy; the other shows the reduction in blocking. The two curves are almost identical. A surprising fact appears in these recovery curves. At first the rate of recuperation is very rapid, a peak gain of 87 per cent being reached by the seventh minute of rest. After this a reversal sets in which brings efficiency down to about 45 per cent at the end of twenty minutes. If it were not for the elaborate care used by Kirby to obtain true results, and the stability of the points on the curves, we might suspect an error in the experiment. But there is remarkable agreement in the results of the different subjects who participated. The feeling-tone curve can be seen to follow an exaggerated form of the same pattern. There is a rapid rise during seven minutes of rest, and then a slump which seems not to terminate before twenty minutes. Kirby's conclusion is well drawn: as soon as the actual fatigue has worn off, the additional relaxation is detrimental to the resumption of work because it leaves the worker unprepared and he has to warm up all over again. In an investigation of rest periods, Graf (2) found that for the first five to ten minutes of rest the worker's attitude is increasingly favorable to a resumption of work. After that, there is a drop in readiness, followed by an ultimate rise. The optimal rest, therefore, must terminate at a high point in readiness. But this depends partly on whether the worker knows how long the rest period is to be,

so that he can prepare for resumption of work. Otherwise he is caught in an inefficient attitude and requires time to readjust. Kirby's results fit these observations perfectly, except that she did not prolong the rest period enough to find the ultimate rise that Graf discovered. She could have predicted this, however, because when she retested her subjects on the following day recovery was complete.

Factors Affecting the Rate of Recovery

Although these recovery curves of Kirby's are for a thirty-minute work period only, they are probably typical of what would be found for longer periods of mental effort, except that the peak of recovery would be proportionally delayed. But the same rule would hold, namely, that once this peak is passed, a longer pause is detrimental if the worker is planning to resume work. On the other hand, long work periods without adequate rest, in which fatigue is allowed to accumulate to an excessive degree, call for more protracted recovery.

What of the extra amounts of work that are accomplished under the drive of a strong incentive, such as a bonus or a competition with other individuals or groups or an intense zeal to achieve a goal? Can we assume that in these cases the energy consumed is proportional to the amount accomplished? If so, then a correspondingly long rest is needed to compensate, even though the worker has the subjective feeling of having produced the extra output with no added effort. But if his changed attitude toward the task and his improved feeling-tone can be assumed to contribute any objective value, this should be shown by the economy of effort brought about. A study by Crawley (1) on recovery from ergographic work is pertinent. His subjects first worked

on an arm or leg ergograph until exhausted, then rested from two to four minutes, then worked again to a point of exhaustion. Crawley judged the amount of recovery gained during the rest by the amount of work done in the session after the rest. When he had determined how much this was under ordinary conditions of stimulation, his next step was to repeat the experiment but to introduce an incentive in the first work session. He found that, as a result of the incentive, the subjects actually accomplished more work before exhaustion was reached. The question is, did this extra output create enough additional fatigue so that a rest period of the same length as before was unable to bring about as much recovery? Crawley reports that the output after rest was always smaller in this second experiment, but not enough so but that some clear advantage was gained from the incentive. It is safe to say that, in general, extra work produced under the stimulus of a bonus or piecework system is accomplished at the expense of greater energy, for which a longer rest is needed; but the rest need not be proportionally longer. More will be said in a later chapter about the advantages and disadvantages of using extra incentives in work.

Do some kinds of work require longer recovery periods than others? It can be taken for granted that those which produce the most rapid decrements will require the longest rests. Tasks which have the characteristics discussed in Chapter IV are in this class. For example, all work is much more fatiguing when it is strange to the worker, before he has become thoroughly familiar with the operations involved. Work involving a high degree of sameness or monotony requires more frequent rest pauses, as do also unbroken tasks with an extreme degree of continuity. Finally, jobs which are essentially meaningless to the worker, either because he is not motivated toward them or because they are

split up into such fragmentary units that he cannot comprehend them as a whole, are excessively fatiguing and require more frequent pauses.

Distribution of Rest Pauses

The value of rests during work hours has been so well proved for industry by such studies as those carried on by the Industrial Fatigue Research Board of Great Britain that most industrial managers accept it without serious question. It is harder to demonstrate their value for mental workers, because production rates are not so carefully kept for them. But there are a number of studies, principally by German and English psychologists, to which we can refer for an answer to such questions as the following:

Where, during the work period, should rest be introduced?

How many rest periods are advantageous, and how often?

How long should rest periods be for given amounts of work?

The first question, regarding an optimal position for the rest period, can be answered from our knowledge of the work curve. The typical curve shows a considerable period of time during which there is either a level rate of output or a rise in efficiency. This is followed by either a gradual or a steep decrement to the end. This latter part of the curve represents an inefficient state of affairs, a diminishing rate of return for the time spent. Therefore many recommend that the rest period should be introduced at the point where the decrement begins to appear. In a typical curve this would be at the high point, but few curves are exactly typical. Graf (2) recommends that a single rest period be provided after the second third of the work session, provided the latter is

one or two hours long. Longer periods than this call for two or more rests.

The second and third questions are interrelated. The more frequent the rests, the shorter they can be. But too frequent pauses are decidedly detrimental, especially when the work is of such a character that it cannot be broken up into small units without destroying the continuity. A system that has proved workable in actual practice is to provide two rests of about five to fifteen minutes during both the morning and the afternoon sessions. The second rest should be longer than the first.

How Should Rest Periods Be Spent?

The answer to this depends so much on the type of occupation that it is unsafe to generalize. However, certain rules can be formulated. If there is a physical element in the work, then complete relaxation is best. If, on the other hand, the strain is mostly mental, complete relaxation may so reduce tonicity as to make it difficult to recommence work, as in the case of Kirby's subjects after seven minutes of rest. Some mildly stimulating activity, such as listening to music or talking or even strolling about, serves to maintain tension and alertness at an optimum and at the same time to relieve cramped muscles and jaded brain. Wyatt's results (8) should therefore be taken with reservations. He found that, in a fifteen-minute rest period between two hours' work in addition, complete relaxation gave a gain of about 10 per cent, and uncontrolled rest yielded slightly less. Listening to music or drinking tea brought only a 4 per cent gain and a walk brought less than 2 per cent. The small size of these gains suggests that fifteen minutes is too long a rest under the circumstances, no matter how it is spent. Probably the warming-up factor in adding figures is an important consideration.

How Restful Is a Change of Task?

From the point of view of a maximum day's output, it would be decidedly advantageous if rest could be obtained by a change of work rather than by a period of complete idleness. For this reason, several investigators have experimented with this form of relief as compared with complete rest. Everything that was said in discussing transfer of fatigue is applicable here. If the changed task is very dissimilar to the original one, there is considerable benefit; but if it is too similar, little is gained. The benefit of changing to a different type of work is felt mainly right after the change is made, while the novelty of the new task is still relieving the feeling of monotony. Therefore, frequent shifts, say every half hour or hour, should prove better than one shift in an entire half day's work. In recovery value, a fifteen-minute period of different work introduced at intervals should be comparable to an actual rest. Probably that is why one psychologist obtained a larger percentage increase in production by using a fifteen-minute period of entirely different work twice a day than another scientist obtained by allowing an industrial group under his observation to work on a different task during the entire latter half of the morning and afternoon.

Everything that has been said thus far applies only to such rests as are followed by further work, where the purpose is to put the worker into the most favorable state to resume work. It does not apply to the thoroughly recuperative rest that must come at the end of the day if he is to be prepared for the following day's exertion, worry, and wear. This is an entirely different problem and must be solved in a totally different way. For example, we have seen that if complete relaxation goes too far during the day, it is de-

cidedly detrimental. But the greater the degree of relaxation at the end of the day, the greater the recuperative value. If relaxation is promoted by becoming physically tired by games or exercise, they are to be recommended. If greater relaxation can be obtained from social activities, playing cards, reading, or going to the theater or movies, then their benefits should be secured. Much depends on choosing the activity that gives the greatest satisfaction, because a happy mood is restorative. Sleep is, of course, the most completely relaxing of all, but this does not mean mere number of hours spent in bed if they are wasted mulling over the problems of the day. In the next chapter we shall see that the beneficial kind of sleep has to be prepared for during the evening, and that the preparation depends on the personality pattern of the individual himself.

Summary

In the present chapter we have examined the recovery curves for both physical and mental work, with emphasis on the latter. We have analyzed the factors which affect the rate of recovery and determine how rest shall be distributed for maximum benefit. On the basis of this knowledge, we are now prepared to summarize the general rules that are applicable to rest periods. These are as follows:

For ordinary periods of one or two hours work, rest periods should last from five to fifteen minutes.

Longer periods of rest are detrimental because they abolish the work set and leave a person unprepared to resume work advantageously.

Work done under high pressure, as where an individual is responding to a strong incentive, requires a longer rest but not proportional to the amount done.

Monotonous work and work that is highly continuous require the most frequent rests.

Novel tasks are always more fatiguing until they become reduced to habit; hence more time for rest should be provided.

Rests are best introduced at the point in the work curve where the decrement begins, or roughly in the second third of the period.

The more frequent the rests, the shorter they can be, but too frequent rests are disruptive to connected work.

How the rest period should be spent depends on the job, but complete physical relaxation is not always best.

Change of task may be nearly as restorative as rest.

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Chapter VIII

SLEEP: ITS NATURE AND CONTROL

SLEEP is one of the most common occurrences of our daily lives. Yet we still know very little about it, except that, for the average person, it is a basic need, absolutely essential for the maintenance of mental health and nervous balance.

In direct opposition to this commonly accepted view is the assertion of a psychologist who has given the problem much study, that sleep is a vicious habit, overindulged in by many and universally overrated. Certain it is that outstanding cases are on record of men who accomplish more than average mental work on a daily ration of sleep which is far below the average. Four hours of sleep per night is said to have sufficed for the wizard inventor, Thomas Edison. Yet some of his acquaintances claim that he made up for it by indulging in cat naps whenever and wherever his mind was not directly occupied with his work. Other famous men have reputedly got along on no more than three or four hours of sleep daily, without apparent detriment to their efficiency. Is this merely to be looked upon as an individual idiosyncrasy, the exception that is supposed to prove the rule; or is sleep really less indispensable than has been supposed? The need of rest is unquestioned; and sleep is the most profound form of mental rest, because it is the only state in which consciousness ceases altogether. It is described by Webster's dictionary as a temporary and periodical suspension of sensory and motor functions and of voluntary control over thought and action, followed by a more or less unconscious state in which the muscles are relaxed, the pulse is slower, the respiratory movements less frequent but deeper, and the

blood circulation of the brain is profoundly altered. That the electrical phenomena of the brain undergo an important change in sleep is evident from studies of the encephalograms (brain wave records) of sleepers. Whereas in the relaxed waking state marked alpha rhythms are present, these are replaced by extremely large slow delta waves of much greater amplitude at the onset of sleep (1). See Plate 1. No such change occurs in the sleep-like state of the hypnotic trance, but unconsciousness produced by drugs and anesthetics has very similar results.

All that we can learn about the physiology of sleep will be helpful in answering the more practical questions about it, such as what are the optimal conditions for sleep, how much sleep is needed, what are the effects of loss of sleep, when does the deepest sleep occur, and what part of the night's sleep is most essential for health and has the greatest restorative value?

Why Do We Sleep?

We are probably nearer to an adequate answer to this age-old question than ever before. Many theories which were once accepted without question have been largely given up. For example, it once seemed logical to assume that, since sleep follows fatigue, it must be produced by fatigue. Hence it was considered a drugged state of the organism, especially the nervous system, that resulted from the absorption by the blood of the poisons or toxic products of muscular and possibly neural exertion. But we often sleep when not fatigued and fail to sleep when fatigued. Sleep can be induced in some persons at any time by relaxation, rhythmic stimulation, or suggestion, or merely by cutting off incoming sensory stimulations to eye and ear. A warm room, a monotonous sound, or even the voluntary decision to go to sleep is sufficient for

some people. The regular diurnal recurrence of sleep in most individuals is not dependent on being fatigued.

Another theory which has proved untenable holds that sleep results from a change in the blood circulation of the brain. Some theorists argued that it was a case of too little blood reaching the brain, causing brain anemia and undernourishment of the cells; others insisted that it was just the opposite—too much blood rushes to the head when we lie down, causing congestion of the brain capillaries. Both points of view assume that we sleep because we lie down, whereas most persons feel that they lie down because they are sleepy. Besides, lying down does not invariably bring sleep. If it did, there would be no problem of insomnia.

The fact that all animals sleep has led some investigators to class sleep among the instincts. But domesticated animals follow much more nearly the diurnal sleep habits of humans which are plainly dictated chiefly by custom and convenience. Babies, puppies, and the young of other species take frequent naps with short waking periods between. It is only by painful training that babies learn to accommodate to the adult sleep schedule. This can probably be explained on the basis of much recent evidence pointing to the existence of a sleep center in the brain, located below the cerebral hemispheres in a region called the thalamus. This region seems to dictate the kind of intermittent napping that the young indulge in. When it is injured by disease, as in the case of sleeping sickness (an inflammation that attacks the brain cells), the victim either sleeps continuously for months or even years or is unable to sleep at all. Animals in whom the intelligent brain, the cerebrum, is destroyed, revert to their puppy sleep patterns and lose the diurnal rhythm entirely.

There is every reason to believe that the diurnal sleep rhythm is a learned act, that it is not instinctive or the result of accumulated toxins or governed by the sleep center. It is

superimposed on the original sleep function by habit. Therefore when the cerebrum, the region where habits are retained, is injured or destroyed, the sleep center is no longer held in check but is released to exert control at a primitive level once more. We can sum it all up by saying that we sleep because there is a sleep center in our nervous system; but we sleep in diurnal cycles because we have an intelligent brain which dominates the sleep center and imposes a learned rhythm on it. If necessary, this higher brain can learn a new pattern which reverses the diurnal pattern, as when a workman on a night shift learns to sleep in the daytime.

But we still have left unanswered the question as to how we can voluntarily control the time and conditions of our sleeping. This leads us to the psychological conception of sleep as a *conditioned response*. It also calls for a brief review of the facts in Chapter II, on the reinforcement of the excitation level of the brain by nervous impulses pouring into the central nervous system from the tense body musculature. It was pointed out that when this reinforcement is lacking the brain falls back on its own energy level, which is too low to maintain consciousness. According to this theory, sleep is a state of reduced "vigilance." More will be said about it presently.

Sleep as a Conditioned Response

To call sleep a conditioned response means about the same as to say that it is a learned habit. By this we mean that the factors which control the time and place of our periods of sleep are learned or "conditioned," as the result of past experience. The term "conditioned response" refers to the fact that if a certain response normally occurs in a certain situation, any of the factors in that situation can later cause that response. This is true even if those factors were not essential

causes of the response in the first place. For example, Pavlov (10) noticed that whenever he gave a plate of beefsteak to a dog, the dog's saliva would flow profusely. Thereupon, each time he presented the beefsteak, he rang a bell. After a time the dog's saliva flowed at the sound of the bell but without the beefsteak. We say that the bell became a conditioned stimulus, and the response of salivating became a conditioned response.

Sleep, as it voluntarily and habitually occurs with adults, can be explained in the same manner. Early in the life of the child, sleep occurs only as an involuntary physiological reaction. It occurs, however, in the presence of a certain situation having constant stimulus factors in it, such as lying down, darkness, quietness, clothes removed, a certain time of day, a certain room in the house, and the like. When once this situation with all its factors becomes the habitual setting for the occurrence of sleep, the act of sleeping becomes conditioned to them. These factors have become the conditioned stimuli and sleep has become the conditioned response. The result is that, eventually, the presence of some of these factors is enough to produce sleep, even when the person is not particularly in need of it. Hypnotic sleep is produced in this way. The hypnotist uses all the conditioned stimuli he can to arouse the conditioned response of drowsiness in his subject.

Probably the most important factor to which sleep has become conditioned in this way is relaxation of the body muscles. Another important one is the cutting off of as many external stimuli as possible, although many people habitually sleep in noisy surroundings, or with street signs flashing in their eyes, or in the presence of loud snoring. Few persons, however, sleep well when their muscles are tensed. Any decided change in the general setting, even if this means

quieter surroundings, will make sleep very difficult. This is illustrated by the person who goes to the country for a rest and finds that he cannot sleep because of the stillness. This merely demonstrates how much sleeping is a conditioned response; how much it depends on the presence of the usual or familiar stimulus factors to arouse it. As we shall presently see, knowledge of this fact proves valuable in suggesting ways of obtaining voluntary control over our sleep and correcting tendencies toward insomnia.

Sleep as a Reduction of Vigilance

We pointed out in Chapter II that the state of alertness or energy level of the brain at any given time is dependent on the flow of nervous impulses to it from both external and internal sources. It was suggested that if these are cut off, the excitation level of the brain sinks to so low a point that effective mental activity is no longer possible. Vigilance is let down. Under these conditions, consciousness becomes fragmentary or cloudy and may disappear altogether. Usually there is an intermediate period which is almost dreamlike, when our thoughts are confused and our surroundings become hazy. To bring on this state, it is necessary to reduce both external and internal stimulations. A hypnotist does this by having the subject close his eyes, lean back in a relaxed position, and concentrate attention on his voice which drones on in a monotonous tone calculated to set up an attitude of inattention in the subject. If the hypnotist allowed his subject to relax completely and become totally unresponsive to all surrounding stimuli, he would doubtless go to sleep. But by repeatedly speaking to him in a very insistent voice, the hypnotist maintains contact with him, and in this way holds him suspended between sleep and waking. If he

went away, leaving his hypnotized subject to himself, the latter would pass into an ordinary sleep or else wake up. This has been demonstrated frequently.

Notice that there is no contradiction between the "conditioned response" and "vigilance" theories of sleep. They supplement each other. The same factors which lower vigilance act as conditioned stimuli to excite sleep. That the relaxation of muscles is the most important of these preparatory adjustments is shown by the results of such experiments as those of Miller and Jacobson, in which complete relaxation was alone responsible for an almost total disappearance of sensations of pain, and in some cases for inducing sleep. Muscular tension is a circular process which is self-perpetuating. This is true because sensory impulses returning from the muscles to the brain center arouse motor impulses which excite the muscles to further tension, and so on. Relaxation, on the contrary, brings an end to this chain of events, and the resulting inhibition eventually spreads to the entire neuromuscular system so that sleep follows automatically. But if any persistent external sources of stimulation are present, they interfere. How this discovery about sleep can be used in achieving better control over it will be discussed presently.

Effects of Loss of Sleep

How important to the health and efficiency of the organism is sleep? The answer to this might take a number of forms. For example, can we live at all without sleep, is it as important as food, so that deterioration or death will follow continued loss of it? This question cannot be put to the test on human beings, because it would be impossible to secure any who would voluntarily submit to so dangerous an experiment. However, there are cases on record of persons who

were kept from sleeping by a peculiar malady which seems to affect the sleep center, and who nevertheless did not die. But here there was relaxation and rest and everything else except complete loss of consciousness, so that the brain was probably obtaining the equivalent of sleep.

A more striking demonstration is to be found in the marathon dance craze which swept the country a few years ago. The author himself saw several couples on the dance floor who had been dancing for more than six months continuously. They were permitted ten minutes' rest in each hour. They made the most of these rest periods, for they fell so dead asleep that they could only be waked up by being slapped in the face with wet towels. On the dance floor they showed a complete absence of normal tonus; each partner leaned against the other, and they staggered around like intoxicated persons helping each other home. All expression disappeared from their faces. None of them died on the floor, but what may have happened later is not known. Perhaps they merely suffered lesions in the brain and spinal cord. This condition can develop and yet not be markedly apparent in the behavior of an individual, especially if his occupation and daily life do not call for a very high level of intellectual performance. The only certain answer would be gained by performing autopsies on these marathon dancers. It seems a shame to lose such a fine opportunity to solve a scientific riddle.

However, we do have definite histological evidence on what happens in the nervous system of young animals when they are kept awake. In an early study, DeManaceine (2) kept a litter of puppies awake several nights by disturbing them every time they tried to lie down. Several died within a week, and all were dead within ten days. Post-mortem examination of their brains showed definite lesions and other signs of widespread deterioration of the brain tissue. The experi-

ment has been repeated by other investigators with similar results. Of course, sleep loss in the very young is probably more serious than it would be in mature animals, because the nervous system is undeveloped, but the principle is the same. A point to keep in mind in drawing inferences from this experiment is that both the puppies and the marathon dancers were kept active and on their feet. Perhaps relaxation and rest, even without loss of consciousness, are sufficient to prevent serious consequences.

Effects of Sleep Loss on Mental Efficiency

A number of studies have been made in which persons voluntarily underwent periods of insomnia ranging from one or two nights and days up to a week or more. Records were kept of subjective symptoms, efficiency in mental tests, and physiological condition as shown by pulse, blood pressure, temperature, and metabolism. In some cases the insomnia was absolute; in others it was only partial, consisting of shortening the number of hours of sleep on several consecutive nights. The latter might be called a sleep-rationing program.

The physiological changes resulting from total insomnia up to a period of 115 hours are not marked. There is decreased respiration, slower heart rate, lowered blood pressure, and slightly lowered temperature. Blood count, chemical composition of the blood, and body weight do not change. Sensory functions remain intact, except that the power to maintain standing equilibrium with the eyes closed is reduced, indicating that the muscle sense is impaired. As long as the subject stands up or remains awake, tonus is sustained in the muscles, but the instant he sits down or drops to sleep, it disappears.

The mental changes arising from total insomnia seem to

involve mainly the loss of ability to maintain attention on a task for any long period and, at the same time, an inability to redirect attention or to make quick adjustments to a change in the situation. Efficiency for set tasks which require only a limited time apparently remains as high as usual, but this probably indicates what can be done by a tremendous effort when an individual mobilizes all his depleted energy. Laird (8) has shown that the person who has lost sleep uses more metabolic energy in doing the same amount of work. This is certain to become apparent in the long run. Laslett (9) found losses in various mental tests ranging from 10 per cent in simple operations to as much as 25 per cent in the score obtained on the Thorndike Intelligence Test. But other investigators found little or no loss in similar types of intellectual problem, although they did report that their subjects complained of various neurotic symptoms, such as headache, dazed feeling, buzzing sound in the head, and visual and auditory hallucinations. Their behavior was decidedly abnormal, like that of an intoxicated person. Their speech became tangled; they grew very irritable; they became weak in emotional control, laughing or crying without reason; and they complained of being very weak, almost dead. The fact that they could still brace up enough to do difficult mental tasks is a tribute to the sheer stamina and voluntary effort they exerted.

Sleep Rationing

What happens if, instead of abstaining from all sleep, a person cuts down on the amount for several nights? One psychologist, Smith (11), kept records of herself during a period in which she slept 1½ hours the first night, 3½ hours the second night, and 5½ hours the third. The remarkable finding was that her efficiency in mental tests increased on

the first day after the insomnia period. After that, there was a long period of lowered capacity while she was recuperating. As a rule, even large amounts of insomnia do not require a proportional amount of sleep in compensation. For example, two nights of total insomnia can be compensated for by a couple of hours of extra sleep the third night. But why should efficiency the day after a period of rationed sleep be higher than usual? The answer is that we need to be in a more or less tense or keyed-up state to do our best in tests. Sleep relaxes us; hence we are never at our best level immediately after a long night's rest. It is necessary to build up tension again until an optimum is reached.

Later on, in the section on diurnal variations in efficiency in Chapter XIII, it will be brought out that the hours immediately following a night's sleep are often the least efficient of the day. There is a gradual improvement up to about 11:00 A.M. When the tension in the body muscles has been measured at different hours of the day, it has been found that the minimum tension occurs at the time of rising and builds up steadily from then on.

It would be unwise to conclude from this that cutting down on sleep is a good way to raise one's efficiency the following day. The inevitable hangover must be reckoned with, even though it is delayed a day. For example, many persons keep late hours on Saturday night in the belief that the effects will wear off by Monday. Actually, they will feel the letdown more on Monday than on Sunday.

The Depth and Duration of Sleep

Everyone knows, from self-observation, that he sleeps much more soundly during certain parts of the night than during others. The majority agree that their deepest sleep occurs during the first few hours, and that afterward their

sleep is broken by restlessness and occasional wakening. Many who dream find that their dreams are more likely to occur a short time before waking than early in the night. Other people, however, find that the latter part of the night is the period in which they sleep most profoundly, the early hours being wasted in tossing about and trying to go to sleep. In the face of such contradictory opinions, the findings of scientific experiments on sleep are of interest.

The first requirement for studying variations in the quality of sleep at different hours of the night was to establish an objective and reliable test for measuring depth of sleep. Among the more common tests which have been used by psychologists for this purpose are the following:

- The dreamlessness of the sleep
- The amount of intensity of a stimulus required to waken the sleeper
- The number of movements the sleeper makes during a given period of time
- The character of the brain waves from the sleeper's brain

The most often quoted study of sleep is that by Kohlschütter (7), who used the second of these methods. He assumed that the depth of sleep could be measured by determining how loud a sound was required to just waken the sleeper. Applying this test to his subject every half hour during the night, he found that the deepest sleep occurred during the first hour. In fact, according to his figures, a sound stimulus eight times stronger was required to waken the subject in the first hour than in the second. From that time on, sleep became steadily shallower; by the fifth hour it was extremely light. Other investigators, using the same method, found another slight increase in depth around six hours. But these studies do not bring out the ups and downs that occur after the first hour, which other methods have shown. Further-

more, do we have the right to assume that the entire nervous system, or even the entire brain, is equally sound asleep? Dreams are activities of limited portions of the nervous system that take place while other parts are quiescent. There is every reason to suppose that we can be partly asleep and partly awake at the same time.

The method of recording movements of the body—tossings and turnings and changes of position—is much more in vogue at present as a measure of the depth of sleep (5).

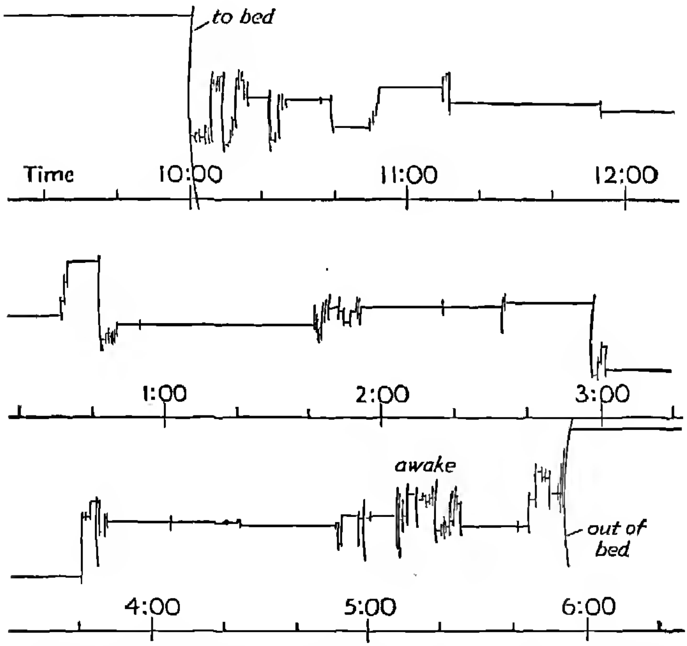

FIG. 11.—Motilogram of a normal night's sleep. (From S. R. Hathaway, *Physiological Psychology*, Appleton-Century, 1942.)

The apparatus consists of a lever fastened to the bedsprings at a point where every movement of the sleeper will disturb it; a recording device, such as a recording pen which marks

on a traveling strip of paper, or a comptometer, is attached to the end of the lever. Plate 7 shows one of these devices attached to the bedsprings of a cot on which the subject is sleeping. The record obtained looks somewhat like that shown in Fig. 11. The results obtained by this method agree with Kohlschütter's findings that the deepest sleep occurs in the first part of the night for the majority of people; but they show, in addition, that during the rest of the night there are periods of deeper sleep puncuated by waking moments or moments of very light sleep during which considerable movement occurs. Typical healthy subjects may have from twenty to forty shifts of position during one night. The shifts become more frequent the longer the subject sleeps. Often the positions he assumes appear far from restful, but they serve their function of alternately resting one and then another group of muscles.

Kleitman (6) used this method recently in answering a number of practical questions about the optimal conditions for sleep and the differences between individual sleepers. For example, he found that there were seasonal variations in amount of dreaming, amount of movement during sleep, and ease of going to sleep. Contrary to the usual supposition, movements and dreams did not go together. The largest amount of dreaming and the least amount of restlessness occurred in the spring; this relation was reversed in the autumn. Going to sleep was easiest in the spring and autumn.

Optimal Conditions for Sleep

Kleitman (6) set up certain criteria by which he could judge the quality of his subjects' sleep so that he could decide what factors made for good and poor sleep. The subjects were asked to report whether they went to sleep with ease or difficulty, whether they dreamed much or little, and whether

they felt well or poorly rested when they awoke. To these reports Kleitman added the objective records showing how often they stirred during sleep, how long they slept, and how many times they woke up during the night. These combined reports and records gave him a basis for saying that this or that factor was conducive to good or poor sleep on the whole.

Weather conditions affected the various subjects so differently that no rules could be formulated, aside from the seasonal variations already noted. Neither ease of going to sleep nor restlessness during the night was affected by taking naps during the day. The food and drink consumed at the evening meal had no effect, nor did the size of the meal; however, it must be kept in mind that these subjects went to sleep five hours after the meal so that digestion had progressed fairly far by that time. Drinks taken just before going to bed increased the amount of dreaming. Certain drugs known as hypnotics affected the ease of going to sleep and the length of sleep. Any deviation from the usual evening routine, especially if it was marked enough to be described as distinctly "irregular," had a definitely deleterious effect on the quality of the ensuing sleep. The most favorable preparation for sleep seemed to be to follow a fixed routine. This indicates again that sleep is a habit, and that like all habits it can be disrupted by any variation in the conditions under which it is aroused.

Intense mental activity, whether it is reading a stimulating book, doing mental work, or carrying on an exciting conversation or argument, should be avoided in the late evening because of the tendency to "perseverate," that is, to go on thinking about the same things after retiring. Once the brain is thoroughly aroused, particularly along emotional lines, it cannot let go easily. For this reason, emotional conflicts, such as indecision about a problem, can rob one of sleep.

Sleep Norms

How long should a person sleep each night? The average seems to be eight hours, with a mean variation of from seven to nine; but children and elderly people depart considerably from this. Since few individuals spend all of this time in actual sleep, the figure for the mean variation is probably nearer six to eight hours. Johnson (5) reports that "it is not unusual for a person to take nearly as much rest [meaning sleep free from restless tossing] on most nights of 6.5 hours as on the average night of 9.5 hours." But it would be false to conclude that only the hours of deepest sleep are valuable. The hours of shallow sleep also have their function in building up reserves and preparing the nervous system for the wear and tear of the following day. If this were not true, we would be justified in recommending that the sleep period be split up into two or more, since this would probably make the sleep in each period deeper. This was actually tried by one psychologist (3) with one of his women students as the experimental subject. During the first month she slept eight consecutive hours each night; during the next month each night's sleep was divided into two periods of three hours each, separated by a period of three hours spent in writing, reading, and sewing. She took several mental tests each week, and her physical condition was also checked. On the basis of the number of hours devoted to sleep, the continuous period had the advantage because she could sleep eight hours without a break, whereas on the other nights only a total of six hours was allowed. None of the mental tests showed any advantage for either condition over the other, but there was a considerable loss of control over body sway in the second month. This indicates that the two hours' sleep per night that was saved was gained at the expense of a gradual weakening of reflex control.

It is often necessary for workers who change from a day to a night shift to reverse their hours of sleeping—instead of darkness and quiet, they must sleep in daylight and noisy surroundings. The adjustment is hard to make, and some never completely adapt to the changed habit. The tendency is to spend fewer hours in bed, whereas more are actually needed to compensate for the shallowness of disturbed sleep. The only solution is to observe a regular routine, separate eating and sleeping as much as possible, and allow a longer period in bed.

Insomnia, Its Cause and Treatment

Many persons complain of chronic insomnia, the inability to sleep regularly that results in ragged nerves the following day. Not all cases can be alleviated by the same methods because their causes are different. Some are due to ill health and can be relieved only by reestablishing the healthy state, or by taking mild doses of the hypnotic drugs which have been found non-habit-forming and effective in promoting sleep. But many sufferers from insomnia are in good health. Here the condition results from a nervous state, or from wrong sleep habits, or from some other remediable cause. It is foolish for these individuals to let their insomnia continue.

Let us consider, first, the case of the nervous insomniac. Whatever the cause of the nervous disturbance—and this should be ascertained and removed first, if possible—the insomnia probably results from the heightened tenseness of the body musculature induced by the nervousness. This has the effect of increasing the nervousness. If complete relaxation can be induced, the nervousness is likely to subside enough to permit sleep. Jacobson (4) has shown that relaxation must be much more profound than the superficial

degree commonly attained by those who are told to relax. This is so because of the persistence of residual tensions in obscure muscle groups which are voluntarily sustained by unconscious sets. Since they are voluntarily sustained, they will submit to voluntary relaxation, provided the patient's attention can be directed to them. This requires, first, learning how it feels to tense a muscle like the biceps and then how to relax it completely. Locating the sensation and gaining ready control over the muscle may take some time. The patient progresses from that to other muscles, until those finer groups which surround the eyes, face, lips, forehead, and neck are brought under control. Sleep has sometimes occurred before the process was entirely completed.

Jacobson (4) distinguishes between *general* relaxation, *relative* relaxation, and *selective* relaxation. The first has just been described. The second can be practiced while the person goes about his daily affairs; it consists in maintaining a relaxed state in all muscle groups not actually used in performing the activities called for. It is illustrated by the difference between the actor or speaker whose every muscle is tensed so that his delivery is jerky and graceless and whose speech is spasmodic and harsh, and the performer who has achieved such relaxation of the unused parts that every motion is smooth and graceful and apparently effortless. The third type of relaxation, called selective, consists in taking an attitude of repose toward certain particularly irritating factors in the environment. For example, if noises are the source of irritation, one can learn to be relaxed toward them. If it is a person whose presence is an irritant, one can learn to remain relaxed with reference to that person and the patterns of tension which his presence excites.

Probably the same ends can be achieved by suggestion or by drugs, but the voluntary control which progressive re-

laxation makes possible gives the patient a feeling of independence and self-confidence that is more desirable in the long run.

If the insomnia results from wrong sleep habits, it may be necessary to relearn proper sleep habits from the beginning, just as a child has to learn them. Reduce everything pertaining to sleep to a strict regimen; become reconditioned to all the stimulus factors which can be depended on later to call out the response automatically. Make the environmental conditions as favorable for sleep as possible. In extreme cases, in order to fix the sleep habit, drugs or hypnosis may have to be resorted to. The idiosyncrasies of the particular individual must be discovered and taken into consideration. For example, warm drinks may redistribute the blood supply and promote sleep in one person but interfere with it in another.

Summary

We are now prepared to summarize our remarks on sleep, both as to its cause and function, and as to its control.

Sleep as we know it is an essential period of relaxation for the organism that occurs diurnally; its function is to restore mental and physical efficiency. Sleep is a conditioned response, largely governed by habit, except when the organism is thrown back on the more primitive control by the sleep centers of the brain and displays an alternation of slumber and waking at frequent intervals.

Sleep is characterized by a lowering of the vigilance of the brain accompanying relaxation of the musculature, which finally reaches the stage of obliteration of consciousness.

Sleep is deepest during the first few hours in the case of most persons, though there are many exceptions; but there are periods of deeper and shallower sleep throughout the

night, punctuated with postural changes and occasional waking.

Most people require between seven and nine hours in bed, of which from six to eight are actually spent in sleep. Wide individual differences can occur.

The most important rules to observe in controlling sleep are to adhere to an evening routine and not to deviate too far from it; to utilize the conditioned stimuli for the sleep response, to avoid exciting activities before bedtime, to learn one's personal idiosyncrasies as to the overstimulating or soothing effect of foods and drinks, and then to apply this information.

Insomnia must be treated on the basis of its cause. If nervous excitability is the cause, the first step is to remove any aggravating mental conflicts. Progressive relaxation should be practiced to eliminate hypertension. If insomnia results from the formation of wrong sleep habits, adequate sleep habits must be learned all over again. Ill health requires methods of treatment beyond the scope of psychology.

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Chapter IX

ATTENTION AND DISTRACTION

From time to time in the sciences, certain topics are overstressed for a while; this is followed by a revolt or reaction against this overemphasis, during which many thinkers in the field refuse to recognize the topic at all. The danger is, of course, that this will result in "throwing the baby out with the bath"; in other words, that much that is valuable will be sacrificed by this wholesale discarding of a topic. Apparently this is what has happened to the topic of attention in psychology. Doubtless the objectors had a good case and were justified in feeling that attention was being treated as though it were some kind of force or power which could be appealed to. Attention is not a force, it does not do things. It is merely a name for a set of facts, a tendency or characteristic about the way we respond to our environment, to the stimuli that crowd in on us from all directions. What are these facts, and what is this tendency?

What Is Attention?

We cannot characterize this tendency without describing it from several angles. From the objective angle, it presents certain features that are extremely important. We want to know both what these features are and how they are produced, so that we can gain some control over the process in the interests of efficiency.

Objective Features.—First of all, we always react *selectively* to the stimuli that surround us. In the welter of sights and sounds, most of them go unnoticed. Certain ones are always

focused upon, but others are just barely noticed. This is partly due to certain qualities of the stimuli. Loud sounds and striking sights are noticed most readily, other things being equal. This is the *intensity* feature. Any sudden change in what is going on around us, as when someone enters the room or leaves it or turns on the radio, attracts our notice. This is also true if a noise that has been going on for a long time suddenly stops. This is *change*. As long as anything in our view remains perfectly still, it goes unnoticed; but if it moves, we see it at once. This principle is taken advantage of by display advertisers who use illuminated signs with *motion* in them. It is well known in military skirmish tactics that troops will go undetected by the enemy if they remain perfectly still in one place; small animals escape death by resorting to the trick of freezing in their tracks. Still another principle of attention is *duration*. This, however, may work in either of two directions. An insistent stimulus that keeps hammering away at us may finally attract our notice on that account; but many times we cease to notice stimuli at all because they have persisted so long. We have become *adapted* to them and hence no longer respond to them. Whether a particular stimulus will be adapted to or will become more irritating the longer it is continued or the oftener it is repeated, depends partly on its meaning, how it fits into what we are doing and thinking at the time. Stimuli that have no great significance for us are easily adapted to, but the significant ones are not. Besides, we can never be sure that because we do not notice a certain stimulus as such, it is not affecting us in some other way. As was pointed out in Chapter II, the illumination of the background is just as essential to efficiency in reading or doing visual work as the illumination of the foreground. We are scarcely aware of the background as such, but it stimulates us in an important way.

Crowding Out Irrelevant Stimuli.—This tendency we have

described, to react selectively to our surroundings, means that we are receptive to some stimuli, but resistant to others. We have shown how receptivity is related to the qualities of the stimulus. But this hardly accounts for it all; in particular, it fails to account for the stimuli that we resist. Both must be accounted for in terms of internal factors in the individual himself, such as his interests, his habits of thought, his needs, and his work set, that is, what he is doing at the time. More will be said about this in a moment.

Attention as a Bodily Attitude.—How is the selective tendency made possible? We have to put our whole body into a receptive attitude. If we are attending to something directly before us, our eyes are focused on it, our muscles are tensed, we scowl, repress our breathing, listen intently, and stay motionless. Internal changes take place, as for example a decreased skin resistance which can be measured electrically. If irrelevant stimuli annoy us, we become more tense in the effort to resist them or to attend more closely. If we are doing mental work and attending to it, the picture is about the same.

Attention as a State of the Brain.—Along with these bodily changes, there is a changed state of the brain. This organ also becomes more receptive to arousal by the stimuli we are attending to, and resistant to all others. This is the principle of facilitation and inhibition described in Chapter II. When this state exists, even very weak stimuli that relate to what we are attending to produce a strong response, whereas very strong stimuli that are not relevant to what we are attending to produce a weak response or none at all.

Subjective Features.—We are aware of all these changes only by the effect they have on our thinking. We notice that some things become very clear and vivid, some impressions stand out, while others are forced into the background. There is always a fringe of impressions, such as the pressure

of the chair on which we sit or the roar of traffic outside, that are barely perceptible unless a sudden change occurs, whereupon they enter the foreground for a time. Periodically, however, the focus shifts and other impressions stand out, while those previously noticed recede into the background.

Internal Determinants of Attention

Among the selective factors within the individual which determine what things shall be in the focus and what in the background of awareness, the most important are his dominant interests, his needs, his habits of thought, and his work set. These require further explanation.

Dominant Interests.—Some dominant interests are longstanding whereas others are merely temporary. A baseball fan does not notice that any particular effort or strain is involved in listening to baseball scores over the radio, but he may notice a considerable effort in listening to a sermon or lecture. If he happens to be a student who has been told to obtain certain points from the lecture, those points will stand out because he is interested in them. When a woman goes downtown she notices hats; her husband fails to see them.

Needs.—When a person is hungry, he notices signs that say "Eat" or "Restaurant," whereas when he has just eaten, they go unnoticed. Certain needs are so constant that they can be counted on to affect attention most of the time. We refer to hunger, sex, thirst, and the social motives, such as the need for a feeling of self-worth. Thus a man will see his own name in the newspaper or overhear a complimentary or disparaging remark made about him, when other impersonal things would pass unnoticed.

Habits of Thought.—Everyone of us forms certain definite habits of thought, certain restricted channels, that determine the direction of our attention, the things that will or will not

be noticed by us. Often this is a matter of a man's profession or vocation. A shoe salesman sees people's feet, not because he is particularly interested in them outside of work hours, but because the habit is firmly fixed. A proofreader sees errors in print. Of course, interests cause habits to be formed and these habits in turn act like interests in directing attention. A geologist sees rock strata even when he is out walking for a bit of exercise; his companion, the hunter, sees the pheasant first.

Work Sets.—Unless we are fortunate enough to live without work, the most important and compelling determiner of attention for most of us is the work set. While we are on the job we attend to the stimuli that have to do with it. This becomes habitual so that the effort involved in focusing on the job and resisting irrelevant stimuli becomes relatively slight. Some of these other determiners of attention are always present, and the instant we grow fatigued or bored with the job, they become more insistent. For example, when the stomach is empty around eleven-thirty, thoughts of food keep distracting us from our job. When the work grows boring, we daydream about summer vacation plans or what not. In other words, there is a definite feeling of effort and strain about attending to work, and this is what makes it work. This difference between the work set and other kinds of attention has led psychologists to distinguish three grades of attention: *spontaneous,* which is given to things that interest us naturally, without effort; *habitual,* which requires effort at first, but becomes easy with long practice; and *voluntary,* which requires a conscious directive effort on our part.

How Can We Control Attention?

One of the most common questions asked of a psychologist is: How can I concentrate my attention better? Everyone is

aware of the necessity of selectivity in reacting, but few know how to go about it to secure this selectivity at the times and in the situations in which it is most needed. Certain rules can be suggested which should help considerably.

Make an Ally of Habit.—The more we can reduce the work set to a group of ironclad habits, the better. For example, a given job should be associated with a given place, a given time, and so forth. The more invariable this is, the more surely will it become easy to attend to that job in that place and at that time.

Free the Mind of Conflicts.—Much of the difficulty experienced by students in trying to concentrate on study, library reading, or lectures can be explained by the habit of daydreaming. If the daydreams are the casual, fragmentary ones that indicate an unoccupied mind, their distracting effect can easily be overcome merely by enforcing attentive habits. But too often the distracting thoughts are real emotional problems which are insistent because they keep the individual in a state of conflict until they are settled. If he is really worrying over finances, domestic problems, a career, or something equally vital, there is only one thing to do—the problem must be settled and settled decisively.

Be Sure That the Physical Conditions Are Right.—There is no use trying to disregard physiological demands. Don't try to do work that requires a high degree of concentration when

Your stomach is clamoring for food
The room is improperly ventilated or heated
You are already fatigued from work
There is excessive noise or commotion

Be Sure That Your Interest Is Aroused.—This is easier said than done, and it often depends more on others than on yourself. But if what you have to do is really significant to

you, either for its own sake or because of its bearing on something else that is personally important to you, then you can keep that motive in mind, or call it to mind if forgotten or overlooked.

Range, Duration, and Shift of Attention

A number of practical problems that arise in work situations can be clarified by a knowledge of how the attentive set operates. Among them are such questions as the following:

Can we attend to more than one thing at a time? Can we successfully carry on more than one operation at a time, or is this certain to lower the efficiency in each operation? For how long a time can we give reasonably close attention to a task, a program, an address, before changing to something else? How long can we attend to one very limited thing which does not change at all?

Range.—The usual statement that a person can attend to only one thing at a time is very misleading. The number of things he can attend to at a time is limited only by his ability to see them as related parts of a total pattern. In a common experiment in psychology, rows of letters or numbers on a card are presented to persons who are asked to tell how much they see. The card is shown through a window which can be controlled by a shutter so that the card is exposed for only a twentieth of a second. Yet in this time an individual can see as many as five numbers or letters, and if the letters spell words, he can see a whole sentence of thirty or more letters. For example, such a sentence as "This is the constitution of the United States" can be seen and reported later, even though it is exposed for only a twentieth of a second. If, instead of numbers or letters, pictures are used, the meaning

of an entire picture, in which people are carrying on complex activities, can be grasped in just as brief a time. We are all familiar with the experience of a flash of lightning illuminating the landscape for a brief instant in the dead of night, and being able to gain a clear perception of the location of objects, buildings, and people. Certainly this is conclusive evidence against the theory that we can attend to only one thing at a time.

It is very likely, in such a situation as the one described, that some things are attended to more closely than others. There are degrees of sharpness of focus. But, for purposes of use, this may be unimportant. We do not usually require a microscopic examination of things in order to react satisfactorily to them. Another factor must be remembered in this connection. It is possible for the focus of attention to shift back and forth very rapidly from one aspect of a complex situation to another, so that the effect is the same as though all aspects were being attended to at once.

Even though we can attend to many things simultaneously, can we react to them all? That is, can we carry on more than one act at once? Again the answer is that the only thing that limits us, besides the scarcity of hands and legs and other reacting members, is our ability to think of all the various reactions as parts of a total pattern. This requires practice of course, but persons of average ability often accomplish it. One of the performers on Major Bowes' amateur program could play six instruments at the same time. This took considerable practice; but he doubtless could have played more than these six if he had had more hands, feet, heads, and knees to do it with. The author once knew a man who could play four games of chess at the same time and win all of them. This man was no genius; he was an average individual who happened to like chess very much.

These cases are looked upon, falsely, as extraordinary demonstrations of talent merely because the idea that we can attend to only one thing at a time is so firmly fixed in our minds. But there is no reason to suppose that any group of acts which, by long enough practice, can be integrated into a larger whole cannot be carried on together practically as efficiently as a single act.

Duration.—Here again we must state exactly what we mean. If the question concerns the length of time a person can focus attention on a single point, for example, a black dot on a piece of paper, the answer has been given by Billings (1). This investigator found that the subject will shift from point to point every two to five seconds, in spite of all his efforts to the contrary. But if the question concerns the length of time an individual can give relatively undivided attention to a task, a radio program, a lecture, or a story, we must answer that much depends on his interest and the degree of variety in the material attended to. Another factor is the way in which he must react to it, i.e., how closely he must follow it. If the task is automatized to such a degree that it can be carried on by a part of his brain while his thoughts are taking frequent excursions into the realm of daydreams, the periods of application can be fairly long. But if very close attention is necessary and if the task cannot be automatized, the duration of any one unbroken period of attention will be quite short. If we disregard an occasional break of a few seconds, the period might be as long as five or ten minutes. If we ask a group of people to listen to a fifteen-minute broadcast of war news and question them afterward about it, we will find that no one can give a complete report because each one will have had some lapses of attention during that time.

By knowing about the occurrence of these lapses of at-

tention, we can present material in such a way as to minimize them. If attention is allowed to drift after it has once wandered from the subject in hand, it must be redirected later by a voluntary effort. But if the material is presented in such a way that some striking or arousing impression is introduced at frequent intervals, the attention will be brought back spontaneously. Any such device soon loses its effectiveness unless it is varied from time to time. It is surprising how simple a change will be effective. A simple illustration of the principle is an experiment in which two groups of persons add figures steadily for twenty minutes. One group is uninterrupted throughout the period; the other is interrupted every minute by a rap of the experimenter's pencil on the edge of his desk. Under these conditions, the interrupted group does more work during the twenty minutes.

Waves of Attention.—In Chapter III in connection with the discussion of blocks, it was suggested that, besides the short fluctuations of attention which occur every few seconds, there are longer attention spans lasting several minutes, and, superimposed on these, there are much longer waves of maximal and minimal efficiency covering periods of an hour or more. It must not be supposed that the periods of inattention are actually blank periods as far as all mental activity is concerned. They are merely periods of greater susceptibility to distraction, when the worker's attention wanders from the task to some subject which is more attractive at the moment. This may be his own daydreams, or something interesting going on around him. Therefore, in brain terms, the wave of attention is merely a shift in the focus of most intense excitation from time to time. We consider it superficially as alternate attention and inattention because we are interested in the subject's efficiency in the particular task assigned.

Distraction of Attention

If a person is working at a task or studying or reading or listening to a lecture or attending to something in particular, any stimulus which is irrelevant to that activity is a possible distracter of his attention. Whether it proves to be an actual distracter or not depends on several factors, some of which we are about to discuss. We cannot predict whether a particular irrelevant stimulus will actually divide a person's attention and therefore distract him, unless we know what these factors are. The following paragraphs list the more important ones.

Intensity.—Loud or jangling noises, raucous voices, persistent sounds or sights are likely to be distracting until we grow used to them, but we can at least become adapted eventually to most of them. This is the conclusion to be drawn from a number of experiments in which intense stimuli were purposely used as distracters. For example, Ford (3) used a Klaxon automobile horn, placed about two feet from the subject's ear, and a phonograph with a loud-speaker close to the subject's head. He assigned his subjects a mental task which could not become automatic but must be attended to every instant. Each sitting consisted of three periods: first, six problems worked in quiet, then six with distraction, then six with quiet. The results, which included 183 sittings from 41 subjects, show that a prolonged initial reaction follows a change from either quiet to noise or vice versa, but that this wears off rapidly and leaves efficiency practically as high as in quiet. On the other hand, if the task had involved listening, for example, noises would likely have proved much more distracting than stimuli to a different sense organ, such as the eye or skin. When the eyes are being used in a task, visual distracters are the worst.

Time Relations.—Any stimulus is more distracting if it keeps recurring at the wrong instant. For example, it has been shown that if an irrelevant stimulus is given to a person just before he is to react to a signal, his reaction will be slowed down considerably. A rhythmic sound which is out of tempo with a person's work rhythm can easily throw him into confusion; but if it synchronizes easily with the work rhythm, it can prove very beneficial, not only increasing output but relieving fatigue from the task. This is the secret of the sailors' chanteys and the rhythmic songs of Negro stevedores as they time their movements.

Novelty.—Since we can adapt to most irrelevant stimuli after a time, familiar ones are likely to lose their distracting effect. But novel stimuli are always more disrupting, because of their newness or strangeness. Another fact is that all stimuli are more distracting when we are working on a novel task. Once the task is "automatized," as Ford demonstrated, the distractions lose their effectiveness.

Interestingness.—Human voices are usually more distracting than mechanically produced noises if the intensity is the same. This is so because they have more meaning for us, and because our curiosity is excited by what they are saying. Conversation is particularly interfering, because of the difficulty in resisting the temptation to stop and listen to what is being said. A radio program that contains a story has the same effect.

Suddenness and Change.—It is the sudden, unexpected stimulus that is most disturbing, because there is no time to adjust to it; it catches us unaware. Changes in the environmental stimuli, even from noise to quiet, are also distracting. The remarks made by some of Ford's subjects, when he changed from the noisy to the quiet condition, throw light on this. Some of them "missed the racket" and were bothered by the "uproarious quiet"; they could "hear the silence."

Intermittent stimuli are always more distracting than steady ones, because of both suddenness and change.

Can Distraction Improve Efficiency?

The early experimenters who studied distracters were greatly surprised to discover that the persons who were subjected to the distracting agents often did better than when they worked without such a handicap. This seemed like an extremely absurd contradiction. When Morgan (8) found that subjects who worked at a decoding task while he distracted them with loud bells, buzzers, and phonograph records grinding out music and humorous dialogue, were often able to do as much or more than in quiet surroundings, he concluded that they put forth more effort. He was able to show that they worked under greater tension. They reacted to the distracting effect of the noises by exerting more energy to overcome it. Morgan considers this a basic tendency; whenever a resistance is imposed on us, we automatically put forth extra effort to overcome it, and incidentally accomplish more on that account. Certain it is that muscular tensions are increased by noise, even when we are sitting quietly. Davis (2) proved this by obtaining action potentials from the forearm of subjects who sat quietly in alternating periods of noise and stillness. Every time noise was introduced their muscle action potentials increased two or three times in amplitude.

Morgan was the first one to suggest that the extra work done under distraction is done at a greatly increased expenditure of energy, so that there may well be a net loss in the long run. We might suspect this to be the case because of the increased muscle tension produced. But the surest proof would be to find a rise in the metabolic rate under distracting conditions. Recently this has been demonstrated by several

psychologists, one of the first to do so being Laird (7). He studied the effects of noise distracters of different intensities on typists' energy expenditure in calories, as compared with their metabolism under quiet work conditions. In the noise situation they worked in a room where there were other typists and people were talking. In the quiet situation they worked alone in a room whose noise-proof wall covering shut out or deadened all noise. The typists wore respirators while they worked, and the expired air from their lungs was analyzed to determine the energy exchange. There was a 20 per cent greater increase in their working metabolism over their resting metabolism when they worked in noisy conditions. Smith and Laird (9) also reported a study of the effect of sudden unexpected noises on the action of the stomach. Four subjects equipped with stomach balloons were subjected to ten minutes of noise of 80 decibels strength, following a twenty-minute quiet period. The noisy period was, in turn, followed by ten minutes of quiet. The records of the stomach contractions show a decrease of 37 per cent in the

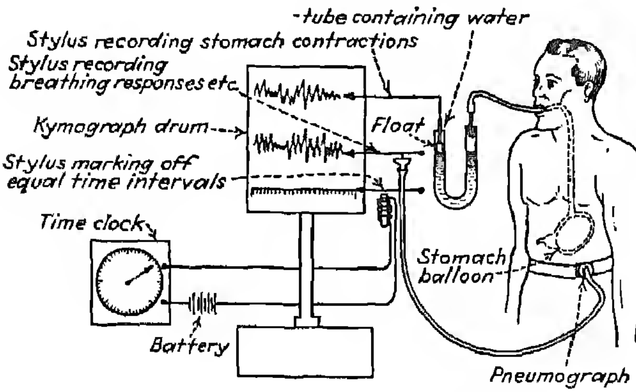

FIG. 12.—Apparatus used for recording changes in the tonus of the stomach muscles under emotional stimulation. (From Crafts, Schneirla, Robinson, and Gilbert, *Recent Experiments in Psychology*, McGraw-Hill, 1938.)

number per minute during the period of noise. This might easily cause a serious interference in the digestion of food. The subsequent quiet period showed an increase in the rate and violence of the contractions above the normal, indicating that a period of readjustment is necessary before the natural rhythms of the stomach can be resumed. This offers a vivid example of the serious disruptions that go on inside the body when we are subjected to sudden, loud, or disquieting noises. Undoubtedly habituation would considerably lessen the effect. Fig. 12 shows how the contractions of the stomach are recorded by means of a stomach balloon.

Not all those who studied the effects of distracters on work efficiency obtained the positive stimulating effects that Morgan secured. For example, Laird found that his typists accomplished less in a noise situation, although the difference was not as striking as the energy expenditure difference. Freeman (4) found a decrease in the accuracy of solving problems in noise. Harmon (5) tried to simulate real office conditions by using two kinds of distracting stimuli reproduced on phonograph records: the noise of typewriters and the roar of city traffic. Tasks like adding columns of numbers were detrimentally affected, especially when the noises were first introduced.

Must we conclude that whenever irrelevant stimuli exert a positively stimulating effect on output, they do so at the cost of extra energy? Probably not. There are most certainly instances in which the improvement can be looked upon as a directly beneficial effect of the exciting stimuli themselves. These are the cases in which the irrelevant stimuli are integrated into the activity that is going on. We seem compelled to appeal to such an explanation to account for the remarkably beneficial effects, on war-time production, of music played in factories during work hours, both in this country and in England. Some of the studies on music were discussed

in Chapter II. Let us add a very recent report to the others. Humes (6) was interested in determining what effect phonograph music would have on the amount of scrappage in the production of radio tubes over a long period of time. His subjects were eighty-eight women engaged in assembling radio tubes. He used four conditions: slow music, fast music, mixed fast and slow, and a control condition without any music. The fast and slow music had a clearly beneficial effect in reducing wastage, and with certain models of tubes the mixed music helped. But individuals were affected differently. It can be taken for granted that whenever music is introduced into a situation where many persons are working together, some will be benefited more than others, and a few may be hindered in their work. The question is whether there is a net gain for the group.

Summary

The conditions under which irrelevant stimuli introduced into a work situation will have a facilitative or neutral effect can be summarized as follows:

When the stimuli are of the kind that can be incorporated into the activity being carried on.

When the stimuli arouse the worker to a greater effort to overcome them.

When the task is so well practiced that it does not require any attention to carry it on.

When the distracter is so habitually present that the worker has become adapted to it and is no longer aware of it.

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Chapter X

MOTIVES AND INCENTIVES IN WORK

If any one thing characterizes human behavior and sets it off from the behavior of machines, it is the fact that the directive force or control is internal rather than external. The automobile responds instantly to the foot on the throttle, but without any directive control behind the foot nothing worth while would be accomplished. The machine is dependent on an external source of directive guidance. Men, like automobiles, have throttles in them; at one time they release great energy, at another they display only feeble effort. The secret of making that energy available for worth-while ends is to reach the controlling force behind the throttle, the internal directive power. To do that, we must understand the motives of men, for these motives are both the generators of energy and the guiding forces in its expenditure. We are aware of these motives in ourselves and of how they direct our actions; we commonly call them by the collective name "will." The aim of the present chapter is to consider which of these motives are available for use in improving our own efficiency and that of the persons whose work we supervise, and how such motives can be most effectively utilized.

The Distinction Between Motives and Incentives

There are really two sides to this problem, as an illustration will show. Consider, first, the results of an experiment by Kitson (5) in a Chicago printing establishment. His problem was to find out how much a group of hand compositors would improve their rate of output under the stimulus of a

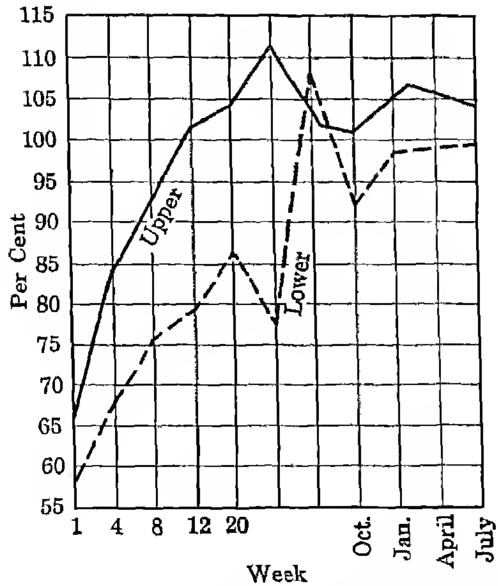


FIG. 13.—Curves showing the improvement of two different groups of workers in typesetting as a result of introducing a bonus system. (From H. D. Kitson, A study of the output of workers under a particular wage incentive, in *Univ. J. Business*, 1922, 1, 54–68.)

cash bonus for extra productivity. The men on whom the experiment was tried had already had an average of ten years' experience, so that practice could long since be said to have reached the limit. Yet, after five months under the new wage stimulus, their output had risen 67 per cent. See Fig. 13. Contrast with these results the outcome of an industrial experiment reported by Lee (6), in which a piecework method of reward, which resulted in additional pay for additional output, was used on a group of young girl workers. Instead of rising, as might be expected, their productivity fell off 20 per cent; the reason was that they had to turn their pay envelopes over to their parents. When they were told that they would be allowed to go home each day after they had completed a

fixed quota, they were ready to go home at 2:30 P.M., although the quota was actually higher than their maximum daily output before.

These contrasting illustrations are cited to show that there are two sides to the problem of motives; one is the internal drive to which we wish to appeal, and the other is the external incentive used in making the appeal. The incentive chosen must appeal to the motive which is strongest in the particular group of persons involved. In the first illustration the incentive was more pay for more work. It was effective because the motive was present and the incentive called it out. But, although a similar incentive was used in the second case, the motive was absent, therefore the incentive failed. When an entirely different incentive was used, for which there really existed a corresponding internal motive in the girls, it was highly effective. How do we know, when we introduce certain standard incentives into work situations with the idea of increasing efficiency, that the motives to which we are supposedly appealing are really present in those particular individuals under those particular conditions? We need a more intimate knowledge of human nature than the average person possesses. What are the dominant motives of men, and how do they vary with the situation and the individual? What types of incentives have the greatest appeal to the widest range of persons?

Some Powerful Motives

Everyone who writes on motives makes a different list of motives. We are mainly interested in those which bear on the work life and on productivity. These can be divided into two classes: the sustaining motives, which are largely biological and have to do with mere sustenance, and the energizing motives, which raise effort beyond the bare minimum and

lead men to put forth extra energy for their fulfillment. It is with the second class that we are concerned, since it can be taken for granted that any normal individual will be productive enough to hold his job and respond continuously to his sustaining motives. The second class of motives is mainly social rather than biological. It is chiefly concerned with our desire to be thought well of by others and to achieve distinction in one way or another. Hence the following motives stand out in importance: desire to win in competition with others, whether singly or in groups; desire to gain praise and avoid censure from those we respect; desire to secure those things in life which will improve our social status; desire to gain self-respect by achieving goals.

The incentives which can be counted on to call forth these motives vary from individual to individual and from situation to situation. For example, money rewards have a rather universal appeal, but only because money can satisfy several motives at once. The gradual standardization of wages and collective bargaining are removing the effectiveness of this appeal in the lower brackets of the income group, as are movements toward social security, unemployment insurance, and the like. In the upper brackets, the ceiling on incomes tends in the same direction. Fear and the desire for security, once strong and compelling motives, have been so alleviated by social security measures that they have become mere sustaining motives. But the longing for a sense of personal worth is stronger than ever. An opportunity given a worker to secure a feeling of his own importance or his own share in something big with which he can identify himself often outranks monetary reward in its stimulating power. Judicious praise from a supervisor who has previously built up a high level of respect on the part of subordinates is frequently a powerful incentive. Delegation of a little authority to the ambitious underling sometimes galvanizes his energies. The

fact that the majority of persons, when asked what feature of a job appeals to them most, respond, "Opportunity for advancement, even if it involves a salary sacrifice," indicates that ambition to achieve goals outranks monetary reward in importance. The rivalry or competitive motive is appealed to strongly by opportunities for the individual worker's achievements to be made known to his co-workers. Group competition, while usually less effective than individual competition, can be highly effective if it is preceded by a building up of group morale so that each member identifies himself and his ambitions with the fortunes of the group to which he belongs.

Individual and Group Morale

In contrast to particular incentives which appeal to one or another specific motive, there is a general level of willingness or cooperativeness toward work which is characterized by the name morale, and depends on a combination of factors, among which are congenial working conditions, confidence in superiors and in their genuine interest, a feeling of group solidarity with one's working associates, and a consciousness that one is doing well on the job and making a success of it. Individual morale is a different thing from group morale, yet a body of workers whose individual morale is high are likely to have a high collective morale. A group of psychologists formulated the following definitions of morale which bring out the distinction very well:

Individual morale: ". . . condition of physical and emotional well-being in the individual that makes it possible for him to work and live hopefully and effectively, feeling that he shares the basic purposes of the groups of which he is a member, and that makes it possible for him to perform his tasks with energy, enthusiasm, and self-discipline, sustained

by a conviction that, in spite of obstacles and conflict, his personal and social ideals are worth pursuing."

Group morale: ". . . the condition of a group where there are clear and fixed group goals (purposes) that are felt to be important and integrated with individual goals; where there is confidence in the attainment of these goals, and subordinately, confidence in the means of attainment, in the leaders and associates, and finally in oneself; where group actions are integrated and cooperative; and where aggression and hostility are expressed against the forces frustrating the group rather than toward other individuals within the group."

Morale in work is not limited to the conditions surrounding the work, but is affected by everything in the worker's life. Marital relations, opportunities for recreation and improvement, and social status, all contribute something. Child (3) lists the following components of morale; they are not in order of importance, necessarily.

Financial incentives
Relation of the individual to his superiors
Opportunities to remedy sources of annoyance and frustration
Individual personality, ability, and skills
Events in the individual's outside life

Frequently, those who supervise workers are unable to judge the factors which count most in the workers' minds in building and maintaining their morale. One study showed that the factor which a large group of employers thought should rank first, namely, fair pay, was given third place by the workers themselves, whereas the item which the workers placed first, i.e., credit for all work done, was placed seventh by the employers. And the factor of job security, considered second in importance to money reward by the employers, was put at the end of the list by the workers.

Experiments with Incentives

The question of how certain types of incentives actually work out when introduced into studies of output and efficiency in mental work can be answered only with reference to the limited experimental situations used. The studies center around three special varieties of incentive: competition and rivalry; praise and reproof in various forms; and specific rewards and punishments. These will be taken up separately.

Competition and Rivalry.—There are at least three different competitive relations in which a person can be placed; he may compete, as an individual, with other persons; he may compete, as a member of a cooperating group, with a rival group; or he may compete with his own previous record in order to maintain a self-imposed standard or reach an ideal goal he has set for himself. Another point to recognize is that one's competitors need not be physically present or even known. A national competition to win the Navy "E" is going on at present, but the contesting groups are not known to one another. Sometimes it is a standard, such as the record high jump, that is competed against. Finally, competition is often implicit; that is, an individual may not be aware that he is being spurred on by the desire to rival some person or persons, or some standard, yet the motive may actually be operating.

Individual rivalry is illustrated by a study by Whittemore (13). Twelve students were given the task of printing paragraphs from a newspaper with individual rubber types. Under one condition, they were told to do as much as possible consistent with quality; under the other, to beat their fellow workers. All turned out more work when competing, the average gain being 26 per cent, but quality of output suffered somewhat. It was the poorest workers who profited

most by the competitive factor. This fact, that competition lowers the level of performance of the superior members of a group and raises that of the inferior, has been verified by many other experiments.

A chance to compare group competition directly with individual competition is afforded by an experiment made by Sims (11) on 126 college students who substituted numbers for letters during twelve practice periods. He divided them into three groups; one group worked without any incentive; the second was subdivided into two competing teams; in the third, each individual was told his own score and that of a rival with whom he was paired off. Since the groups performed equally well as a whole in the initial test, their improvement at the end of the twelfth practice period could be expressed as a percentage of this initial level. The results show that the average improvement for the members of the first group was 102.2 per cent; for the second or team-competition group it was 109.9 per cent; the greatest gain, 157.7 per cent, was made by the members of the individual-competition group. Thus we can infer that group competition is better than no incentive, but individual competition is far superior to either.

In competing against other people, an individual tends to single out for rivalry some person or persons whose ability is about equal to his own. If he is pitted against greatly superior workers, he becomes discouraged and ceases to try; and, similarly, the superior performer receives no stimulation from being paired against those of lesser ability. This barrier to the effective use of the rivalry incentive can be removed by the method which Vaughn and Diserens (12) employed in a series of practice sessions in marksmanship with persons of widely different ability. One condition gave an advantage to high initial ability by rewarding the individual making the best score. Another gave an advantage to low ability by re-

warding the person showing the greatest improvement. In the third condition, all contestants were given handicaps according to their initial performance. Vaughn also found that the emotional strain of competition, as shown by increased variability in performance and large galvanic skin reactions, was most pronounced in those who wanted to win but lacked confidence in their ability. There is some evidence tending to show that the more complex the level of mental performance called for by the task, the more easily will the worker be disorganized. In fact, such complex mental operations as are required in taking intelligence tests are never helped by intense competitive situations.

Self-competition has been found surprisingly effective whenever it has been used. It may consist in nothing more than being informed of one's past record from time to time or having access to it, or it may involve a conscious attempt to improve it. In some cases it takes the form of trying to surpass a certain standard of performance which the worker sets for himself or which is set for him by a supervisor. The experiment reported by Mace (8) is interesting in this connection, because it gives us an opportunity to compare the last two of these forms of self-competition. It also shows how much a motive can accomplish in delaying the onset of a fatigue decrement in a monotonous task. For the mental work Mace chose the continuous addition of numbers. The twenty subjects worked for 20 minutes each day for 10 days. Half of them were instructed to try to improve each day; the other half were given a new standard each day which they were to try to beat. The resulting work curves indicated that the second type of incentive was more effective. The decrement was more gradual and it was overcome entirely and replaced by a rise in the latter part of the curve.

There is a decided advantage in self-competition. It motivates the best performers because their own previous records

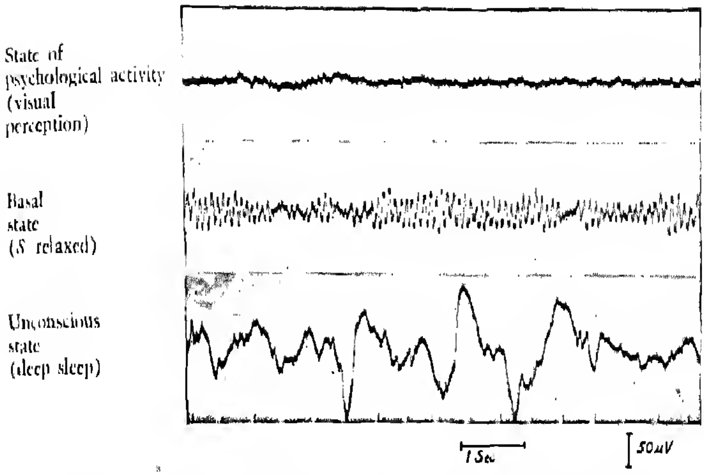


Plate 1.—The electro-encephalograms from the brain of the same person at three different levels of psychological activity. (From G. Kreezer, The electro-encephalogram and its uses in psychology, *Amer. J. Psychol.*, 1938, 51, 751.)

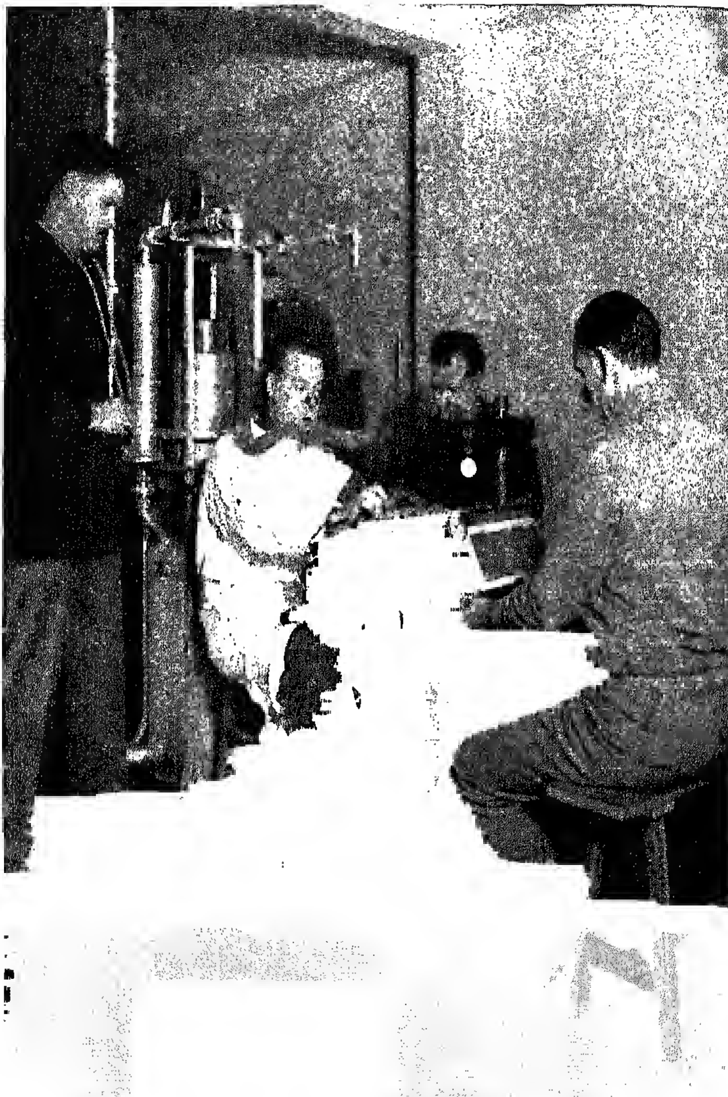


Plate 2.—Measuring the psychological effects of oxygen deficiency. (Public Relations Office, Randolph Field, Texas.)

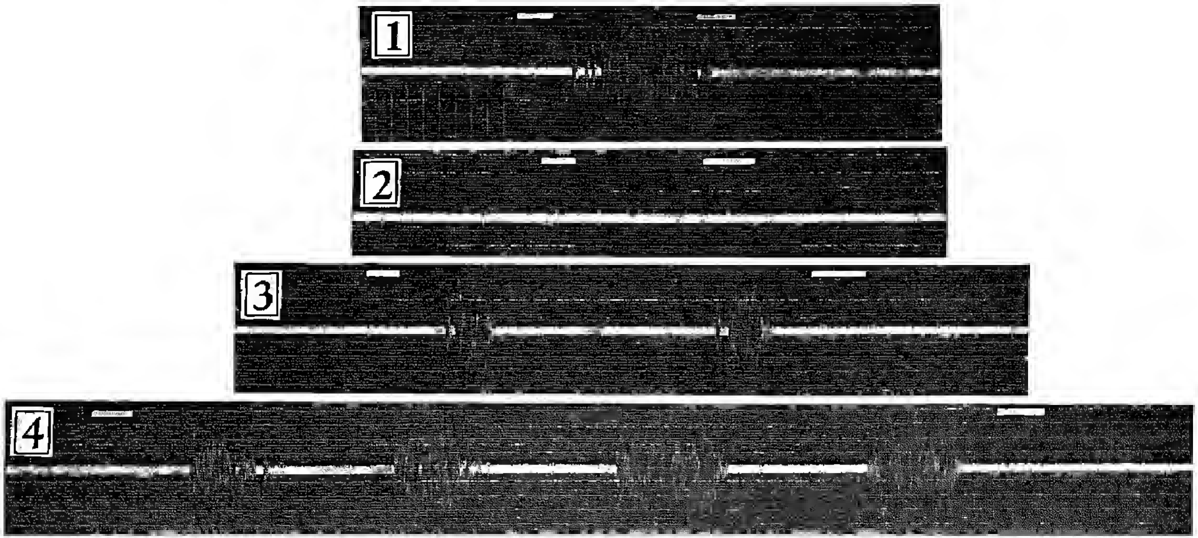


Plate 3.—Photographs of electrical activities in muscles during thinking. Record 1 shows what happens in the biceps muscle when the subject imagines lifting a weight. Record 2 shows that nothing happens in the biceps of the opposite arm. Record 3 shows the effect of imagining hitting a nail twice with a hammer. Record 4 shows the effect of imagining a rhythmic activity like rowing a boat. (From E. Jacobson, Electrophysiology of mental activities, *Amer. J. Psychol.*, 1932, **44**, 677–694.)

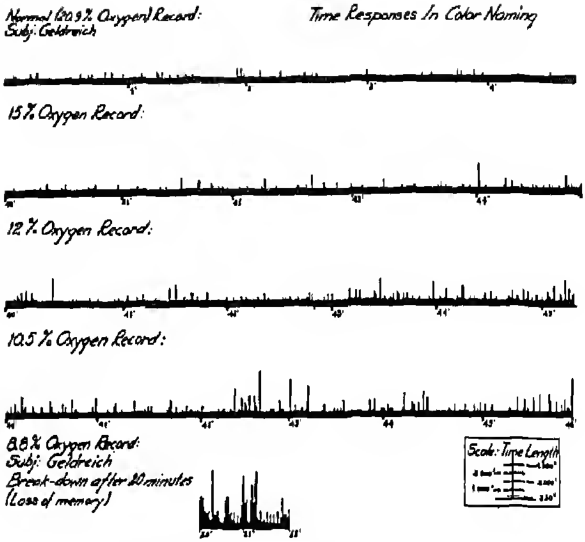
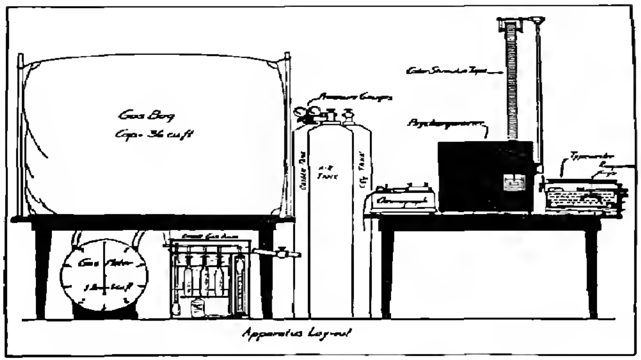
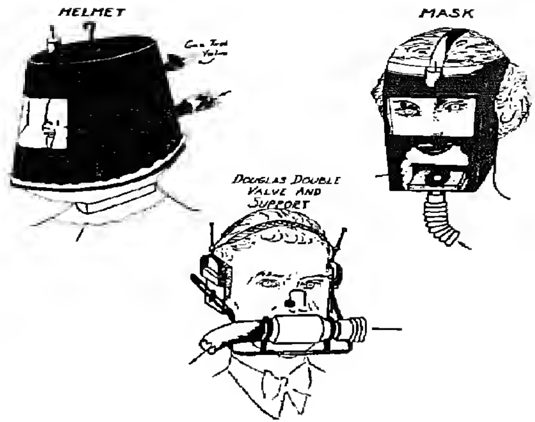


PLATE 4.—Showing the increase in length and frequency of blocks as the oxygen supply is reduced. Each vertical line represents the time taken for one response. The long vertical lines are blocks. The short horizontal line at the bottom, showing almost continuous blocking, was terminated by loss of consciousness. (From an unpublished study by Geldreich and Bills.)





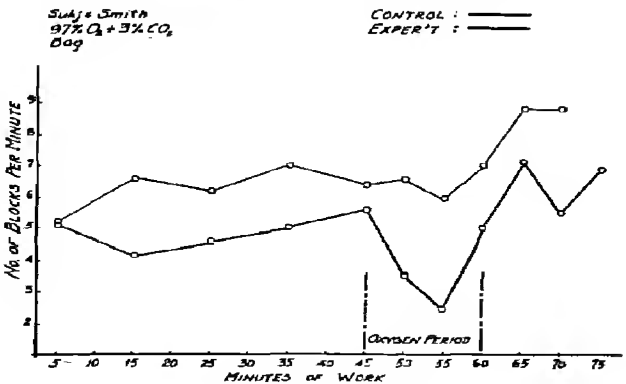


Plate 5.—At the top, left, is a picture of the apparatus for controlling the oxygen content of the air. Beside it are three types of breathing mask worn by the subjects. At the bottom is shown the effect of breathing pure oxygen in reducing the blocking tendency. (From an unpublished study by Geldreich and Bills.)

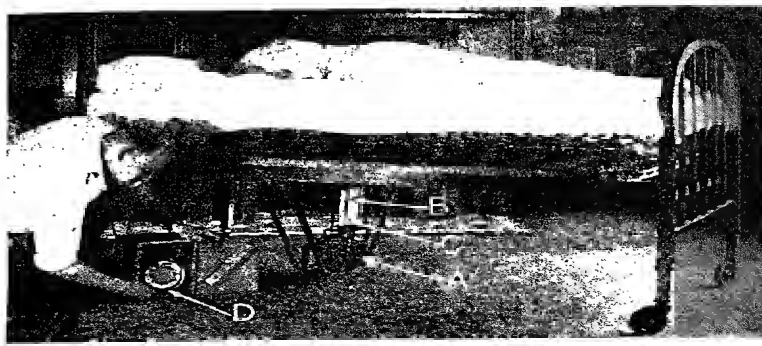


Plate 6.—Apparatus for measuring the skin-resistance changes during mental work. (From an unpublished thesis by T. K. Kirby, 1942, in the University of Cincinnati Library.)

Plate 7.—Apparatus for recording motility during sleep. *A* represents a noiseless electric motor which drives a paper chart past the two pens *B* and *C*, one of which traces the line of rest; the other is attached to a weight suspended from one of the coils of the bedspring, so that if the sleeper shifts his bodily position the pen moves up to a new position. (From W. L. Valentine, *Readings in Experimental Psychology*, Harper, 1931, p. 352.)

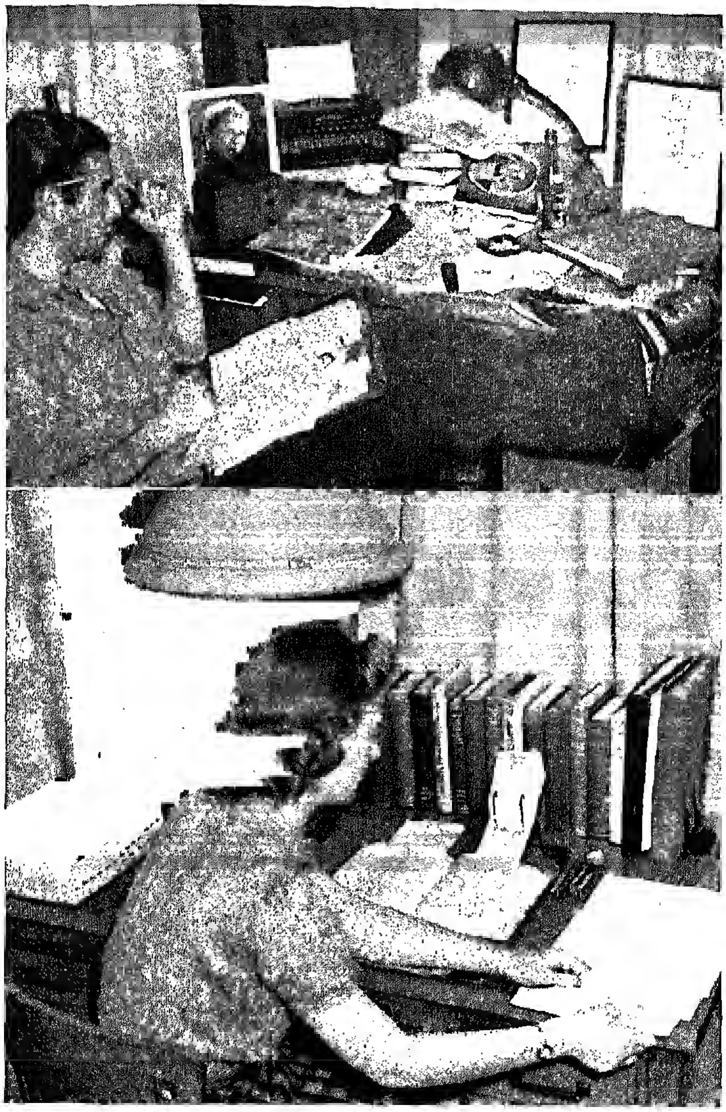


PLATE 8.—Right and wrong arrangements of a desk for efficient mental work. (Reprinted by permission from *The Psychology of Personal Adjustment*, by F. McKinney, published by John Wiley & Sons, Inc.)

"Suppose then, Mr. Aviano, that we simply say: 'It was learned from a source close to the Capitol . . .' "

PLATE 9.—Second-hand information requires careful evaluation. (Richter, in *New York Herald Tribune, This Week*, November 23, 1941.)

are good enough to offer a real challenge to them, whereas competition with others of less ability cannot offer any such challenge to them. But for the same reason it is less effective in the case of the poorer performers.

Praise and Reproof.—The results of experiments with praise and reproof as incentives are in almost complete agreement. The consensus supports the common-sense belief that praise, judicially administered, is far superior to censure in stimulating people to greater productivity. In the face of this truth, it is indeed surprising how little use is made of it. Ruch (9), quoting from S. J. Woolf in the New York *Times,* May 10, 1931, attributes the following statement to President Schwab of Bethlehem Steel: "There is nothing that so kills the ambition of a man as adverse criticism from his superior. . . . If a man does a good job, I do not hesitate to tell him; if he does a poor one, I prefer to remain silent. . . . When I see good in other people's work, I do not hesitate to mention it. A little bit of praise affects the sweating puddler as it does the President of the United States." However, there is one point in the controversy about the relative merits of praise and reproof that is often overlooked. Praise that is undeserved is ineffective, even detrimental, just as undeserved reproof is killing to the ambition of the sensitive individual. Much depends on the form these incentives take. Probably as between a mild reproof and no notice of any sort of the worker's performance, reproof would be preferred. Everyone likes to feel that his work is being noticed and evaluated. In fact, the group of employees mentioned above who put credit for all work done at the top of the list of the factors contributing to the maintenance of their morale, were not asking for anything they did not deserve; they merely desired recognition for what they actually accomplished.

A slightly different incentive which probably amounts to the same thing is encouragement, and its opposite, discouragement. Again the agreement among investigators is re-

markable. The majority of persons do not react to disparaging comments with a determination to improve; they are much more likely to shrink up. But encouraging remarks have the same effect as praise. This difference is made doubly impressive when we realize that the group which suffers most from discouraging comment and reacts most beneficially to encouragement is composed of the poorest performers who, in the natural course of events, will receive far more of the former and very little of the latter. Sears (10) found that the effect of both encouraging and discouraging comment spread beyond the task in question to any other work that the subjects were doing at the time, even though nothing was said to lead them to suspect that these other tasks were being judged.

Rewards and Punishments.—In the industrial and business world rewards take the form of financial rewards, such as bonuses, pay according to amount done, or wage or salary increase, or of non-financial rewards, such as honorable mention, badges of merit, promotion in rank, and the like. Rewards can often be used effectively with groups rather than individuals, especially if the end to be achieved requires a high degree of group cooperation. Punishment, on the other hand, takes the form of demotion or pay reduction or denial of rewards sought.

The evidence is convincing that rewards have a superior incentive value to punishments. The latter may be effective temporarily but they soon lose their influence. A system of rewards, on the contrary, gains in effectiveness with time. The study by Kitson referred to at the beginning of the chapter indicates what can be accomplished by a bonus system over a period of months. Before the bonus system was installed, the 40 experienced hand compositors had an average output of 55 units of work a week. The bonus took the form of extra pay for all output over this amount. Five months

later their average weekly output was 97 units a week, and in another five months, instead of losing any of its effectiveness, the reward system had still further boosted production to 103 units. It is usually assumed that individual rewards are more effective than those made to groups. Probably this is true in the main, but Balderston (1) has reported a study which seems to contradict this. He compared the relative effectiveness of group bonus methods, where competitive groups were rewarded in terms of their joint efforts, and of individual incentive methods. The former proved superior for the majority, although very efficient individuals tended to be held back by the relatively lower standard of the group. Much depends on the degree of the feeling of group solidarity among the members of a given group. Cases are on record where piecework methods have proved inferior to the straight time plan merely because the sense of fellowship among the workers was so great that the rapid ones refused to embarrass the slow ones by turning out a large amount of work and having a larger pay envelope.

What happens when several incentives are used simultaneously? Does this have any advantages over the single incentive? Is the total benefit of the combination as great as the sum of their effects when the incentives are used singly? Leuba (7) gave a partial answer to this question. His subjects were eleven-year-old children, but the application to adults is obvious. They worked on two-digit multiplication problems under four different incentive conditions: one in which no incentive was used; another in which there was a specific reward; a third in which rivalry was the motive; and a fourth in which reward, rivalry, and praise were combined. If the benefit of the incentives is expressed as a percentage improvement over the amount accomplished in the no-incentive condition, the reward, used alone, produced a 52 per cent increase, and the rivalry alone yielded a 47 per cent gain.

When a combination of reward, rivalry, and praise was used, the combined gain was 65 per cent.

Differential Effects of Incentives.—It is never safe to predict what effect incentives will have unless two things are known: the job in which they are to be used, and the personality of the individuals to whom they are intended to appeal.

An example of the first factor is reported by Wyatt (14). He used three different work plans in a candy manufacturing plant, namely, a straight time plan, a bonus plan, and a piecework plan. By calling the output under the time plan 100 per cent, he could estimate the gain resulting from the other methods when they were introduced. An analysis showed that the effect was not uniform throughout the factory, but varied with the job. For example, the bonus and piece methods were highly stimulating to the girls engaged in wrapping, but were either ineffective or slightly detrimental to those engaged in unwrapping. That personality differences must also be considered is indicated by the fact that, of several persons doing the same type of work, some will find one incentive more stimulating and others will react best to another. The all-important thing is the attitude taken by the individual toward the incentive and toward the situation.

Can Incentives Be Overdone?

A word of caution should be introduced at this point. The fact that an improvement in output can be obtained from incentives is no guarantee that the long-time effect will be a net gain either for the employer or for the worker. Crawley (4), as we know, found that the extra output resulting from the incentive of knowing one's past record in ergographic work resulted in a poorer performance in a second session of work after a rest. A longer rest period was required to com-

pensate for the excess fatigue, though not proportional to the increased amount accomplished in the first period. We are in danger of concluding that, if we can quote figures to show a gain in current output under the added lash of incentives, we have proved their value. But there is the possibility that workers will be stimulated to overexert themselves temporarily, and will use up so much of their reserves of energy that they actually accomplish less in the long run. While the majority of people fail to reach their capacity under ordinary stimulating conditions, there are always some who habitually work so near to capacity that they suffer under the added stimulus of incentives. On the other hand, an under-motivated worker is inefficient because he wastes energy in fretting over the boredom of his work.

How Can We Motivate Ourselves?

Many persons feel that the process of motivating themselves is more difficult than stimulating others. Two problems seem to be involved: one of getting started, launching oneself on a new enterprise, plunging into cold water, as it were; the other, the problem of holding to it after the novelty has worn off and the initial enthusiasm has given way to the dullness of the long slow grind. The first problem is merely a special case of the familiar psychological process of forming a decision. We can see it in its exaggerated or caricatured form in a certain pathological symptom called "abulia." People afflicted with abulia are unable to make any decision or settle anything for themselves. Their internal drive is inadequate to overcome the conflict which always occurs between alternative courses of action. The result is that they do nothing. But they respond readily enough when some outside force tips the balance one way or the other, or when some other person decides for them. We can all benefit by

a suggestion from the plight of these sufferers from abulia. Decision often requires the help of an outside factor to pull the trigger. As an illustration, consider the case of an author who has a plan for a book; he intends to write it, but the preliminary steps arouse so many conflicting impulses that he finds himself drifting along, wasting time on all sorts of unimportant jobs in order to salve his conscience and convince himself that he is too busy to begin the book. In a chance conversation with a friend, he admits that he is planning a book. The friend asks when it is to be finished. Our hypothetical author sets a date merely because he has to say something, but the friend passes on the story and soon several people confront the author with the accepted belief that his book is to appear on such a date. What can the author do to save face but get to work immediately? Another way of bringing outside pressure to bear would be to sign a contract with a publisher to deliver on a certain date.

The second problem, that of motivating oneself to persist at a monotonous job until it is completed, can often be met by setting up nearby goals. The majority of persons are depressed by having to face a long or unbroken task. If it can be broken into shorter units and presented one at a time, it becomes much more palatable; Bills and Brown (2) have experimental evidence to prove this. Applying this to the problem of self-motivation, we can set up nearby goals by promising ourselves to complete a certain unit by a definite time, and by rewarding ourselves in some manner when we live up to the contract. We can also take advantage of the competitive motive by keeping a record of our past performance and trying to equal or exceed it in each successive period. Incidentally, self-imposed penalties for failing to measure up to the goals which we have set ourselves are often effective, and they do not have the serious fault that censure or punishment from other persons has, namely, that it is re-

sented and discourages a cooperative spirit. We can hardly resent self-imposed penance. The fact that remote goals need to be reinforced is a universally recognized truth. No matter how serious-minded a student may be, he needs the spur of facing examinations to hold him to the endless grind of study. Many students prefer frequent quizzes for this very reason. So much the more, when we are out on our own in life, do we need to set up our own hurdles.

The problem of motivating ourselves for the long pull is complicated by the fact that different persons seem to have different patterns of energy release. At one end of the scale are those who work best under tremendously high pressure for relatively short periods; they must be practically cornered by work before the dammed-up springs of energy can be released. Then they work at high pitch many hours a day, with a minimum of sleep or rest, with no apparent feelings of weariness, until the job is finished. Following this there is a period of lying fallow until another spurt of energy is loosed. At the other end of the personality scale is the worker who sails along on an even keel, rarely showing enthusiastic spurts but, on the other hand, rarely exhibiting periods of aimless drifting. These two extreme types do not differ in the total amount of energy expended; it is in the pattern of its release that they are so completely opposite that they must follow entirely different rules. For example, the high-pressure worker requires the periods of aimless drifting in which to store energy. He should neither censure himself nor allow others to censure him for his apparent indolence. But in choosing a vocation he should take into consideration the probable demands of the job, whether it calls for a steady, day in and day out grind or not. Many persons who do creative work seem to be of the explosive type, and such work is congenial to them for this reason; they can afford to wait for the energy springs to be released. The vast majority of jobs,

however, call for steady persistent effort, so that people who are of the high-pressure type are really compelled to reeducate themselves, to learn new habits or patterns of energy release. It can be done; personality traits can be remade, because they are largely the product of habit formation in the first place rather than of innate constitution.

Summary

In this chapter a distinction was drawn between motives, which are the internal directive forces in behavior, and incentives, which are external things that appeal to and arouse these motives. Several powerful motives were identified, together with the incentives capable of arousing them, such as competition and rivalry, praise and reproof, and specific rewards and penalties. Individual competition was found to surpass group rivalry, and self-competition was also found effective. Praise and rewards, judiciously applied, were found superior to blame and penalties. A combination of several incentives was found to surpass any one incentive in stimulating effect. But a warning was voiced against the injurious effects of over-motivating workers to squander their precious reserves of energy. Finally, some suggestions were offered for motivating oneself, both toward launching new projects and toward carrying through to completion those which have reached the monotonous stage.

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Chapter XI

FRICTION AND LUBRICATION

Eccentric inventors have been trying for centuries to produce a "perpetual motion machine," but they are doomed to failure from the start, because of one factor which they cannot control. No machine can be made that is free from loss of power through *friction*. Therefore, no machine can be 100 per cent economical in operation, as a perpetual motion machine would have to be. And the human being, considered as a machine for doing work, is subject to the same limitation. He cannot be 100 per cent economical as a producer because of the friction he develops which saps his efficiency. Part of this friction comes from the strain of adjusting to impersonal things in his environment, things like the roar of traffic, nerve-jangling delays, apparatus that breaks down. But by far the largest part comes from contact with other people whose personalities clash with his own and create strained relations which serve as an emotional drain. Since the approach to these two different sources of friction, i.e., the impersonal and the personal, is so different, we shall discuss them separately. At the outset, however, some preliminary remarks about emotion are in order.

We are interested in those disagreeable emotions which occur most frequently in the course of the average person's day. These are, first, worry or anxiety, which is a mild variety of fear; second, annoyance, which is related to anger but seldom shows the explosive actions that anger leads to; third, disappointment; and fourth, envy. Worry, annoyance, disappointment, envy—these are the emotions whose effects we see written on so many faces in the throngs that daily dis-

gorge from office buildings, stores, and factories in a modern city. Can we positively say that the records in these faces represent a significant amount of wasted productive energy, a dangerous leak in the national economy? We can best answer the question by describing briefly what happens, according to the authoritative opinions of the physiologist and physician, when the system is subjected to emotional strain (2).

WHAT DO EMOTIONS DO TO US?

The occurrence of emotions, even in the milder forms mentioned above, is a severe drain on the energy reserves of the organism. This is true because there is a direct tie-up between emotional arousal and that part of the nervous system which lies outside the great central system and controls the internal organs of digestion, the heart, the circulation, breathing, sweating, and the endocrine glands. This system, known as the autonomic because under ordinary conditions it operates with relative freedom from the central system, is not under voluntary control to any extent; it carries on the vital functions automatically. But when we are emotionally aroused, it receives exciting impulses which cause a violent change in the actions of all the vital organs. The heart beats faster, the breathing changes, digestion is interfered with, increased sweating occurs, and the glands become active, particularly the adrenals, which inject chemical substances into the blood stream capable of causing the pancreas to give up its stored sugar, and other metabolic changes to occur. Many of these effects would be valuable to primitive man, fighting for his life and food in the jungle. In the case of civilized man, however, such violent readjustments of the vital functions serve no useful purpose at the moment and have a very deleterious long-time effect. If the autonomic nerves alone were involved, the emotion would soon subside; but the

adrenalin lingers in the blood stream and prolongs the disturbed condition. We may have a hangover which lasts for hours, and when annoyances and anxieties are constantly recurring to reexcite the nerves, our vital processes may be in an almost continuously disturbed state.

Compared with the energy used up by actual mental work, the amount that is consumed in emotional reactions is far greater. This is strikingly brought out by the difference in bodily effects caused by the ordeal of taking comprehensive examinations in the case of students who worry a great deal about them beforehand as compared with students who take them calmly. Brown and VanGelder (1) made a study of the chemical composition of the blood and urine of medical students just before and after the taking of examinations. The tests disclosed a large increase in sugar, analogous to what occurs in chronic diabetes. The students who were most apprehensive were most affected physiologically. The degree of effect was also found to be related to the seriousness of the examinations, that is, how much depended on passing them.

The presence of this excessive sugar points to overactive adrenals and to a drain on the reserves of stored energy. The belief is growing among medical men that anxiety can itself cause diabetes in the absence of a defect in the insulin-secreting gland or some related endocrine organ. Functional heart ailments are also believed to be attributable to long-continued anxiety. Peptic ulcers which defy other methods of treatment sometimes benefit by removal of emotional strain. It is suspected that if the emotional conflict perpetuates them, it may have caused them in the first place.

Since the changes which we have described as taking place in the vital processes during worry and anxiety and anger are almost entirely outside of voluntary control, there is no way to avert them except to prevent the emotions from oc-

curring. Mere voluntary suppression of the outward expression of emotion is ill advised because more cases of chronic disturbance occur among those who suppress their emotions than among persons who allow them free rein. The obvious answer to the problem is to uncover the factors in our daily lives which irritate us and either remove them or, if this is impossible, readjust our attitudes toward them so that they call out agreeable rather than disagreeable reactions.

Impersonal Sources of Emotional Strain

A study made by Cason (3) on the subject of annoyances brings together a list of the common annoyances reported by several hundred people. About half of them relate directly to the disagreeable behavior of other persons, but there are also several of an impersonal sort. Some of the latter are of the type that cannot be avoided, but many lie within the power of the individual to avoid. Think, for example, of the number of conflicts that unpunctual habits cause during a day. Lack of punctuality in rising may lead to bolting breakfast or missing it altogether, agitation over missing a bus or train, anxiety for fear of being late to appointments and the necessity of making inadequate excuses, anxiety because letters have not been answered punctually and gas and electric bills have been allowed to pass the deadline. The whole sad train of anxieties, annoyances, and disappointments could be avoided by adopting and enforcing punctuality as a fundamental habit. It means planning ahead and keeping a calendar, but it is a prime necessity for efficient living. Another common source of annoyance and anxiety is being rushed to distraction part of the time and having time on one's hands at other periods. The answer is time-budgeting. No one can be completely efficient who does not budget time as carefully

as he budgets income. These illustrations will suffice to show how many annoyances can be met by planning and thinking in advance.

Others can be minimized, even though they cannot be avoided, by cultivating a sense of humor about what has been called "the perversity of inanimate things"; that is, the tendency of things like cars, fountain pens, and collar buttons to behave as though they delighted in tormenting us. The man who swears at his balky car is as fundamentally ludicrous as the drunk who very ceremoniously begs pardon of a lamp-post. But throwing off an irritation is much easier for some persons than for others. There is a deep-seated tendency in nervous organization that psychologists call "perseveration"; this refers to a persistence in clinging to a given thought channel and an inability to shift to any other for a time. Some persons perseverate more than others, as actual tests show. It is a trait which seems not to be under voluntary control. No one can perseverate long over an emotional experience if he immediately plunges into absorbing work or in some other way deliberately sidetracks his thoughts.

People as Sources of Friction

Do people really like other people? The sociologists were at one time quite sure of the existence of an instinct called the "gregarious" instinct, which made people crave the society of other people. In later years, however, they have become skeptical of the existence of any such instinct in man; they attribute the tendency we see for people to collect in towns, office buildings, factories, movies, and apartments to the mere convenience or necessity of working together in a cooperative economic system. At any rate, whether because of instinct or necessity, people seem unable to get along without one another. But they seem equally unable to get along *with*

one another—which makes it necessary for psychologists to write books on "How to Get Along with People," etc. The rules in such books could all be conveniently summed up in the admonition: "Always treat other people the way you would like to be treated if you were in their place." This is very close to the Golden Rule, but to be able to put himself into the other's place, even though he may earnestly desire to do so, often takes more insight into human nature than the average person possesses. Considerable assistance can be gained from a glance at the list of human motives in the preceding chapter, for if we wish to deal with other people with the least possible friction, we must know their motives and appeal to them.

Consider, first of all, the rivalry motive. In a competitive society we constantly have intimate dealings with persons who are our economic rivals. No matter how much we dislike to admit it, their good luck is often our bad luck, their success our failure. If the man who is our immediate superior officer dies (his bad luck), we may be promoted to his job (our good luck) unless our friend Jones, who has the same rank as ours, is preferred (his good luck, our bad luck). This being the case, we should know that no matter how cordial our relations with Jones are on the surface, it is plain human nature for him to be touchy about any slight preferment that the boss seems to show us. If we keep this in mind in all our associations with Jones and make allowances for it, we can avoid ruffling him and causing him to ruffle us in turn. This matter of dealing with people is, after all, a case of "interstimulation." By this we mean that one person by his behavior stimulates a similar response in the other person, and the latter's response further provokes the first person to retaliate in kind, and so on, until a molehill becomes a mountain.

Not all relations of rivalry between people are of so obvious a nature as the situation described above. One of the basic

human motives is a desire for a feeling of one's personal worth. This makes us defend our own opinions vigorously whenever they come into opposition with those of other people. Even if we secretly question our own omniscience, we do not take gracefully suggestions from others to this effect. This creates a sort of rivalry of opinions between people. No matter how gently we assert anything, we are sure to step on someone's toes. Therefore, in order to avoid friction, it is safer to express our opinions in a somewhat disguised form. For example, over-positive assertions on our part imply that we are surer of our opinion than we really are, and they irritate others. Unwillingness to give the other's opinion a complete hearing has the same effect. On the other hand, being a bit generous and occasionally imputing a clever idea to the other person, even though it is really our own, can do us no injury, and can bolster the ego of the other individual and lubricate our relations with him. In the delicate relations between superior and inferior in rank, such lubricating devices are almost essential. Frequently it is safer to present facts, rather than the opinions we have formed from a consideration of those facts. This is true because if the facts convinced us, they will probably convince the other person, whereas if we give our opinion as an opinion, he may feel the urge to take a contrary view merely because it is our opinion, not his.

When it becomes necessary to remove a false or objectionable opinion in another person, we must first establish a coöperative attitude, a willingness on his part to listen. This can be done by complimenting him on some idea which he has expressed that *really is good,* and then suggesting that the other idea (which is objectionable to us) is not in keeping with his real point of view. Or it may be possible to convince him that the objectionable idea is not really his at all.

It must be admitted that when a person is too obvious in trying to be subtle, he is likely further to antagonize those

whom he wishes to mollify. Therefore one should never forget the general truth that there is no substitute for sincerity, tolerance, fairness, self-control, and interest in others. It is only because many people who have all these qualities still lack the capacity to make other persons realize it because of faulty techniques in approach, that we need to suggest concrete ways of dealing with people.

Another situation in which the motive of desire for personal worth plays a part is the praise-blame relationship between the supervisor or boss and those who work under him. Every opportunity should be given to enable subordinates to gain recognition. Wendel White (5), whose book *The Psychology of Dealing With People* is a mine of information on such points, suggests the following ways of accomplishing this:

By always specifying definitely the nature of the thing to be done and the amount, so there need be no misunderstanding later.

By making sure that the worker has abundant opportunity to receive enough drill in the task to do it well.

By specifying immediate objectives that are quickly obtainable so that favorable comment is not too long delayed.

By objectively measuring and recording the worker's accomplishment so that he can know when he is succeeding.

By giving some freedom as to means of procedure, to allow for a display of originality.

To repeat, the secret of using psychology in dealing with people is a matter of putting yourself in the other one's place and thinking how you would probably react if you were approached in the manner in which you propose to approach him. Due allowance must be made for extreme differences in personality which make this rule an unsafe guide.

Irritating Behavior Patterns

Many petty irritations that arise during a day originate in little annoying habits of the persons we are thrown with. All of them could be prevented by a little thoughtfulness. We may offend others in the same ways that they offend us. For example, of the several hundred annoyances listed by Cason (3), the following were selected by a group of people as being the most irritating:

- A person habitually arguing
- A person crowding in front of me in line
- A person speaking in a dictatorial manner
- A person putting his hands on me unnecessarily
- A person in conversation with me not paying any attention to what I am saying
- A person telling petty lies
- A person keeping me waiting for an appointment
- A boisterous person attracting attention to himself in public
- A person continually criticizing something
- A person who feels he is very superior
- A person who continually talks about his illnesses and operations

What should one do if confronted with annoying behavior patterns, of the kind listed, in those whom he has to work with or under? He cannot set out to reform them because to most people a reformer is one of the most annoying of all persons, next to a converter. Yet there is no virtue in meekly submitting either. The psychological procedure is to try to decide what thwarted motive is being indirectly satisfied by this behavior pattern and then to see if it is not possible to allow the individual to satisfy it in some other way that is not offensive to us.

Some decidedly inefficient ways of reacting to the situations outlined above, which increase rather than decrease internal tension, are:

- To allow resentment to smolder internally and spoil minutes or hours or even days of our time
- To do nothing directly, but to seek indirect and devious ways of getting even
- To try to avoid the person completely
- To fly off the handle and lose one's dignity

Moods and Mental Efficiency

As contrasted with the emotions, which are specific reactions to specific stimuli, things, and people, moods are general humors or states of mind that persist for some time and color all our feelings and attitudes. Often they cannot be connected with anything tangible. We cannot say why we are at one time in a buoyant mood, at another depressed, and again so touchy that the slightest thing makes our temper flare. Sometimes moods are hangovers from actual strong emotions, as when a quarrel at home in the morning is carried over to the office and colors the whole day. At other times they have no reference; they are probably reflections of the physiological state. At such times, a person is wise to avoid emotional or trying situations. People who arise in the morning so down in the mouth or touchy that they have to be handled with gloves until mid-morning should not try to deal with other people during this period. They must learn their limitations. Other persons become edgy before meals, no doubt because of some change in the chemical composition of the blood, such as a deficiency in sugar. They should learn this peculiarity and take steps to safeguard their tempers. Late-afternoon tiredness affects many in the same way, whereas others are at their best at the end of the day.

In addition to increasing emotional strain, moods react on efficiency at routine tasks. As Mayo (4) discovered, they cause a person to indulge in pessimistic reverie while he works, and this in turn acts as a depressant to cut down on his productivity. It is partly because of this that music introduced into work situations is so stimulating and beneficial; it replaces gloomy reverie with more congenial thoughts.

Worry and How to Prevent It

The statement was made at the beginning of the chapter that worry and anxiety are the most frequent forms of emotion. We worry about finances, uncompleted tasks, appointments, illness, our job, the war, the state of the country, or anything else which offers itself. Worry usually indicates conflict, indecision, something that is left unsettled, dangling, uncertain. We worry about finances because we are uncertain where we stand. We worry about uncompleted tasks because we cannot decide which one to tackle first. We worry about illness because we cannot bring ourselves to take the necessary steps to remedy it. Almost always the worry indicates a state of indecision. The remedy is obvious but not always easy to take. We must form the habit of terminating our states of indecision at the earliest possible moment by taking such decisive steps or making such clear-cut decisions that we leave ourselves no room for wavering and conflict. Too many things are left to the mercy of chance to straighten out. The person who feels mastery over his fate and therefore freedom from worry and fear is the one who takes things firmly in hand and settles them, even though he may suffer a severe temporary struggle in doing so. In the stock market crash of 1929 it was not the man who, seeing his fortune melt away day by day, took a positive stand and sold out completely at a heavy loss, that became a nervous wreck,

He may have lost his money but he saved his mind. Rather, the man who finally broke under the strain was the one who was torn with indecision, whether to sell or hang on a few days longer, who convinced himself that something would happen to save him from making a decision. The answer to worry is to come to a decision.

Summary

In this chapter we have been concerned with the problem of how to conserve the energy which is commonly squandered in emotional strains that develop in the course of the workday. The more common varieties of energy-sapping emotions—anxiety, annoyance, depression, etc.—were identified, and their effects on the physiological mechanisms of the worker described. A survey was made of the main impersonal and personal sources of emotional strain, and their origin was traced to the operation of such basic human motives as rivalry, desire for a feeling of self-worth, and compensation for inferiority feelings. A number of concrete rules were suggested for lubricating personal human relationships. Finally, methods were given for coping with recurrent moods arising from physiological factors, and for overcoming worry tendencies, especially those which result from states of indecision and failure to deal with internal conflicts in an effective manner. In the following chapter more will be said about the ways in which mental attitudes exert their favorable as well as unfavorable influences on human efficiency.

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Chapter XII

SUGGESTION AND ITS EFFECT ON EFFICIENCY

"As a man thinketh, so is he"

THIS oft-quoted passage has an interesting application to the psychology of efficiency. It describes a well-known tendency in human behavior, i.e., the tendency to perform at the level at which we believe we are able to perform. If we are convinced that we are going to do poorly, our performance reflects this conviction; we do poorly. If, on the other hand, we believe we are masters of the situation, our behavior conforms to this expectation. A simple but striking classroom demonstration illustrates the point very well. Two students were selected from a class and asked to cooperate in an experiment. One was a girl of rather frail build, the other a male athlete. The girl was taken aside and assured that what she would presently be asked to do would not fatigue her in the least. Nothing was said to the young man. Both were then asked to stand before the class holding their right arms out horizontally until told that they could lower them. At the end of twelve minutes the young man showed signs of great distress. He was wavering, his arm was trembling, and his face was breaking out in sweat. In a few more seconds he was compelled to sit down. The girl was amused but showed no signs of fatigue or discomfort. She was allowed to sit down, but she felt that she could have continued the experiment still longer.

An equally striking illustration of the way in which performance is affected by expectation is afforded by an experiment by Baker (2), who pretended that he wanted to find

out the effect of music on output in mental work. Two equal groups of students were selected and told about the alleged purpose of the experiment. One group was led to believe that the effects are usually distractive, whereas the other was told of the facilitative effects. Both groups were given a task to do while musical selections were being played. The results, which are shown in Fig. 14, indicate that the groups fulfilled

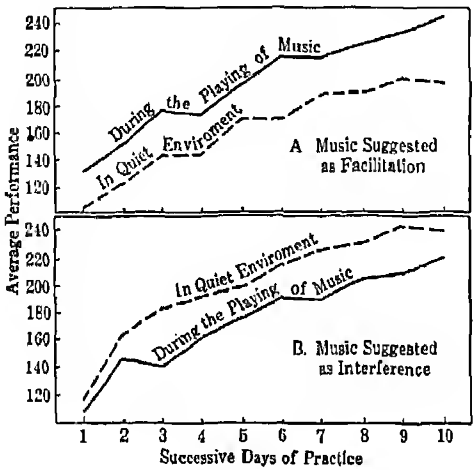

FIG. 14.—The effect of suggestion on performance in mental arithmetic. Curves of production of ten subjects in a quiet environment and during the playing of music (a) when the subjects think that music facilitates performance, and (b) when they believe it interferes with performance. In the first case it actually improved output, while in the second case it interfered with it. (From the graph constructed from the data of K. Baker [Pre-experimental set in distraction experiments, *J. Gen. Psychol.*, 1937, 16, 471–486] by L. S. Pressey and others, *Life: A Psychological Survey*, Harper, 1939.)

the expectations which were created in them. The group who supposed the effects would be beneficial actually improved, while the group who were led to expect interference actually did more poorly.

The Nature of Suggestion

It is customary, in cases like the two above, to say that the persons involved had received a *suggestion* and responded to it. But this merely names the result without explaining it. What is meant psychologically by the term suggestion?

Ideomotor Action.—To repeat what was said in Chapter I, "Psychologists have long suspected that thoughts or ideas are activities which are not confined to the brain but involve adjustments of the smaller muscles as well. In other words, thoughts have been considered the beginnings of responses which are not allowed to come to complete bodily expression, but which are nevertheless stages in the series of bodily adjustments that lead up to and set the stage for the final overt act." By way of illustration, Jacobson (4) found, by applying a delicate apparatus to the biceps muscle of the right arm, that when a person is told to imagine himself shaking the furnace, his muscle has small rhythmic contractions such as would occur on a much larger scale if he actually performed the act. If we keep this fact in mind, it is not at all surprising to learn that whenever a person has a definite idea of a given action in mind, the act will occur unless opposing ideas or sets are present which can block its occurrence. The condition which we have just described is known as "ideomotor action." Under ordinary circumstances, many ideas of action are never expressed as actual behavior because of the counter ideas and attitudes that oppose them. This is true if the idea is somewhat absurd. Yet persons can be made to respond to quite absurd ideas provided the stage is previously set, as it were, so that opposing ideas are removed from control. The classical example of this is the behavior of people under hypnosis, where the usual opposing ideas have been removed

temporarily by the trance state. Even in the normal waking state, many individuals will respond to such experiments as the following: The experimenter asks the person who has agreed to act as subject to watch him closely and do exactly as he does. He then interlaces the fingers of his own two hands and says, "Press your hands together as I am doing, as tight as you can. Now you cannot pull your hands apart no matter how hard you try!" Often the subject finds to his own amazement that he cannot separate his hands. He has accepted the suggestion given him by the experimenter. It has become his own idea, and he has been made to believe it so completely that ideomotor action takes place.

We are now prepared to state the meaning of the term suggestion. Suggestion is an idea conveyed to one person by another, either by speech or in an indirect way, which produces or is designed to produce ideomotor action on his part. If the individual gives himself a suggestion, it is called *autosuggestion.* We are constantly making such suggestions to ourselves and acting upon them; but when we consciously and deliberately do this, the absurdity of it impresses us so much that we usually fail to respond. This is the reason for the failure of such methods of self-treatmest as telling oneself over and over, "I am feeling better and better." Suggestions made by others are therefore more effective in overcoming unconscious suggestions which we have given ourselves, than are deliberate autosuggestions.

Characteristics of Effective Suggestions

Certain factors make some suggestions more effective than others in influencing behavior. One of these is the *prestige* of the person or other source from which the suggestion comes. A suggestion made by an individual whom we admire or in whom we have great confidence is especially effective. A

physician with a confident professional manner can often dispel our symptoms of illness by merely being present or saying a brief word of encouragement. Often the source of the suggestion is impersonal, as in the case of a slogan, "Remember Pearl Harbor," or a party platform, or the word of an authority. Another factor that insures the acceptance of a suggestion is the *absence of any opposing ideas.* The youth of Germany are sold on Nazi political ideas because they are not allowed to be exposed to any ideas which contradict them. This state of affairs is always ideal for indoctrination and for the unquestioned carrying out of suggestion. On the other hand, it is almost impossible to make suggestions effective when doubts and reservations keep interfering. Every experimenter with hypnotism knows that the first requisite of a successful response is to get the subject to give his complete cooperation and then to build up his implicit confidence. After that, every suggestion is accepted and acted upon readily. Under these conditions, surprising results can be achieved. Symptoms of illness can be suggested away and persistent undesirable habits removed, at least for a time. When a suggestion comes from a source which has considerable prestige value, opposing ideas are less likely to be aroused and the person who responds to it is in a state of high suggestibility. The effectiveness of suggestions depends, in large degree, on the manner of their presentation. They must be presented vividly and forcefully, and repeated often. Propaganda is a widely used form of suggestion in war time and in times of political strife. It is effective to the degree that the person receiving it is thrown off guard, made suggestible by an appeal to emotional attitudes and prejudices already accepted by him.

Some people are usually receptive to suggestions; others are resistant. The latter group are said to be negatively suggestible. But even they will be found vulnerable to suggestions

from the right source. In a sense, their negative suggestibility is a form of response which can be appealed to. For example, if we say to a positively suggestible person, "You are doing a very poor piece of work," he accepts the suggestion and his performance is adversely affected. If we say this to a negatively suggestible person, it spurs him on.

Not all suggestions are given directly. There are various indirect ways in which this can be accomplished. For example, seeing the name of a friend on a published list of donors to a charity can act as a suggestion to a person to make a donation. Seeing someone we admire behave in a certain way can act as an indirect suggestion to adopt a similar form of behavior. It is no coincidence that when a college athlete becomes idolized by the students, his clothes, and his manner of walking, dressing, and speaking are all imitated. The greater effectiveness which indirect suggestion often has is due to the fact that it is less likely than direct suggestion to arouse opposing ideas.

Results of Suggestion on Efficiency

It is difficult to find records of the use of direct suggestion in industrial situations, although it is doubtless being used constantly. If we could somehow measure the increased production in war industries brought about by the slogan "Keep 'em rolling," we should have a quantitative proof of the effectiveness of one such example. There are, however, a few laboratory studies on record. Nicholson (6) tried direct suggestions on his subjects to the effect that they would be able to increase their output and that they would not feel fatigue. The subjects were put into a trance to increase the effectiveness of the suggestions, and the suggestions were repeated throughout the work period. Nicholson also ran a control experiment in which nothing was said to the subjects. He

obtained a very definite increase in muscular efficiency as a result of the suggestions. Although he attributed part of the effect to the trance state itself, later investigators (7) have repeated the experiment under improved conditions and have shown that the trance state was not alone responsible.The result must therefore be attributed to the effectiveness of the suggestions. In fact, more striking results have been obtained without hypnosis, by convincing the subjects that the load against which they pulled had been decreased in weight, even though in reality it had not been changed. The mere belief that they were doing an easier task improved their output.

A caution must be introduced against the assumption that such suggestions will be effective regardless of how they are used. If a worker approaches a task with the false impression that it is easier than it really is, he will fail to put forth his maximum effort. Manzer (5) tested the maximum hand contractions of a group of men and women in squeezing the handles of spring dynamometers. The tension against which they squeezed was always the same; but part of them were told that the task would be easy and part were told that it would be very difficult. The suggestion of "easy" actually decreased the contractions of the men; those of the women were not affected; the suggestion of "difficult," however, increased the strength of contraction in both sexes. The ideal type of suggestion seems to be one that prepares the worker to expect a difficult task but that insures adequate confidence on his part by leading him to believe that he is equal to it.

Indirect Suggestion

So strong is the influence of beliefs as to the effectiveness of certain agents in improving or reducing efficiency that elaborate precautions have to be taken by experimenters who

are trying to find out the real effect of these agents. For example, persons who believe that tobacco and alcohol are detrimental are certain to show detrimental effects in their output level under test conditions if they are aware that they have been given these agents. Therefore, clever methods of concealing them have to be devised; otherwise it would be impossible to find out their true effect. What better proof is needed of the operation of autosuggestion? Another example is the marked influence on a subject's performance that is exerted by his idea of what the experimenter is expecting to find. This influence is so strong that careful experimenters always conceal the true purpose of an experiment from the subject. Some subjects are always influenced in the direction which they think is expected; others, who are negatively suggestible, are always influenced in the opposite direction.

Social Suggestion

When people work at any task in the presence of other individuals, a number of effects occur which can only be attributed to the suggestions received from the mere presence of the other persons. One such situation is working or performing in the presence of an audience. Stage fright is an extreme state of paralysis resulting from the autosuggestions of failure which a performer gives himself in the presence of an audience. Microphone fright is a similar effect produced in the absence of any physically present audience. When this is overcome, the audience is likely to prove a stimulating factor. There is a beneficial result on the quantity of output, even though quality may suffer. Nervous persons are more often inhibited, well-poised people more often benefited, by the audience situation.

What happens when the other persons are not spectators but are merely working in the same room? And what if they

are working on the same task? Allport (1) tested both these conditions as they affect the speed and quality of associations. He found that it was the slower workers who were most benefited. There was a speeding up of the process so that more associations were produced, but their quality was somewhat inferior. The best results were obtained when everyone worked on the same task rather than on different ones. The mechanical process of writing was speeded up considerably. The general conclusion is that a social situation promotes a greater quantity but an inferior quality of mental output. In routine types of work, where a high degree of exactness is not called for and where complexity is not a factor, we can look for a positive benefit from placing workers together, and an added advantage if they are all doing the same type of work. Each worker, seeing and hearing the work going on around him, receives a subtle suggestion to speed up. Without doubt, a competitive factor is also involved.

Dashiell (3) believes, on experimental grounds, that the competitive factor is more important than the purely ideomotor. This, however, is of more theoretical than practical importance. If the situation is such as to arouse a competitive attitude by suggestion, the stimulating effect will be more marked.

Effect of Group Attitudes

Whenever a person associates himself with any group for any length of time, his opinions are molded in the direction of those of the group. This has been repeatedly demonstrated experimentally. An expression of group opinion is more effective in changing the ideas of a member of the group than is the expressed opinion of an expert. This is also true of attitudes toward work. The morale of the individual is greatly affected by the morale of the group with which he

works. He is constantly receiving indirect suggestions from the behavior of co-workers, even when no opinions or attitudes are openly expressed. So important is this influence that it cannot be overestimated. Everything that can be done to build up group morale will be reflected, through suggestion, in the individual's performance.

Some Autosuggestions to Avoid and Some to Cultivate

Everyone constantly gives himself suggestions. He does not recognize them as such, but his actions, his attitudes, and his moods are directly affected by them. So important is this tendency that we should scrutinize thoroughly the suggestions that we habitually drum into our own ears, to determine what effect they are having on our efficiency. If we find that there is a preponderance of discouraging suggestions, we should begin deliberately to counteract them with encouraging ones. Below is a list of common autosuggestions that many people systematically discourage themselves with. It is hard to understand what end is achieved by this form of self-abnegation, unless there is a felt need for an alibi against possible failure. However, since the failures are oftener than not brought about by the autosuggestions we have dinned into our own ears, the justification is rather far-fetched.

AUTOSUGGESTIONS WE CAN DO WITHOUT

I am too old to accomplish it now.
I never was very clever at such things.
It's only a matter of time, now, before my job will fold up.
The country is going to the dogs, so what's the use?
The harder I try, the worse I do.
An honest guy hasn't a chance these days.

There's not much use applying for the job, it's probably already taken.

That's the sort of boner I'm always pulling.

It is interesting, if not amusing, to hear the first of these statements made by people of all ages from twenty to eighty. In other words, being old is relative. A person can be old at twenty-five if he allows the thought of age to deter him from taking a decisive step for his own betterment. He can be young at sixty if he conquers this thwarting suggestion. The second statement in the list is also a favorite with people at all levels of ability, not just those of limited talent as might be supposed. But its damaging effect as an autosuggestion is independent of the truth or falsehood of the statement as such. Perhaps if these and similar autosuggestions were never expressed above a whisper, their capacity for harm would be limited; sooner or later, however, we begin to voice them publicly. People take us at our word; they judge us according to our own expressed evaluation of our worth. Why deliberately handicap ourselves by spreading such false impressions of our capacities?

In place of the above list of hampering autosuggestions, we recommend the following, which can do no harm and may have a beneficial effect:

CONSTRUCTIVE AUTOSUGGESTIONS

Instead of enlarging on my deficiencies, I am going to utilize my positive qualities to the fullest.

I am not going to be hampered by unreasonable apprehension over future catastrophes that may never occur.

I am going to accept full responsibility for failures; but, having done so, I shall forget about them and replace them with new successes.

Each one knows best the suggestions that he needs to give himself. They can be used most effectively as counterbalances against the hampering suggestions that tend to tear down his morale. If no more than a balance between the opposing forces is achieved, some advantage has been gained.

Summary

Glancing back over the topics in this chapter, we find, first, that a theory is presented as to the nature of suggestion. Suggestion is described as a form of ideomotor action in which a thought planted in the mind leads to belief and appropriate overt action because no contrary ideas arise to oppose it. This accounts for the way in which our performance is beneficially or detrimentally affected by the suggestions which we receive from those around us, and by the autosuggestions which we give ourselves either intentionally or unconsciously. An analysis is offered of the factors which make for effectiveness of suggestions, such as prestige value of the source, absence of opposing ideas, and appeal to emotional attitudes and prejudices. A distinction is drawn between the positively and the negatively suggestible person. Results of the use of direct and indirect suggestion on the efficiency of mental and muscular work are described. A special form of suggestion, the influence of the presence of other persons, is described, and the importance of group attitudes is discussed. Finally, the process of autosuggestion is called to attention, and a number of autosuggestions to be avoided and a list to be cultivated are presented.

In the following chapter on the physical conditions of efficiency we shall have occasion to point out that such factors as the weather exert their influence on behavior principally in terms of the moods which they arouse through suggestion.

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Chapter XIII

PHYSICAL CONDITIONS OF EFFICIENCY

MENTAL and muscular work are carried on in a physical setting. We wish to know what the ideal conditions of such a setting are, in terms of the physiological welfare, mental satisfaction, and productivity of the individual. We must not suppose that the physical setting exerts its effects only in a direct way, through the physiological state. It is often hard to separate such effects from the more subtle changes in mood, motivation, and personal comfort which are reflected in attitudes toward work. Among the more important factors to be discussed are, first, those concerned with sensory and motor efficiency, such as illumination; second, those which vary with time of day, week, and season, and give rise to the periodic variations in efficiency level; third, atmospheric conditions; fourth, diet and the regulation of food intake; and fifth, the effects of particular stimulants commonly used by mental and physical workers, such as coffee, alcohol, tobacco, and one or two recently popularized drugs.

IDEAL SENSORY CONDITIONS

Clear vision is the first consideration. Within limits, it can be said that, as illumination is increased, there is a steady increase in efficiency in jobs requiring the use of the eyes in close work. But for a period of three hours of reading, Ferree and Rand (4) found that either too high or too low illumination, principally with direct lighting, is fatiguing. Perhaps the optimum for the average person is somewhere in the neighborhood of 15 candle power, although wide individual

variations in preference are expressed. At the same time, indirect lighting is found to be far less fatiguing over a period of hours than direct, probably because of the importance of eliminating the glare of light reflected from polished surfaces. Another factor is the evenness of the distribution of the light throughout the whole room. Just as daylight is widely and evenly diffused, so should artificial light be for avoidance of strain. Johnson (11) found that, for quickness of reaction to a visual stimulus, the field should be no brighter than the background. His results indicate that the best ratio between the two is .75, and that any decrease or increase in it causes a proportional loss in performance.

It is sometimes suggested that colored illumination may be more restful than white light, but this has not proved to be so. Ferree and Rand (5), testing a range of colors from yellow through green to blue-green, found that, in terms of loss of efficiency after three hours, yellow gave the smallest loss and green and blue-green the greatest. Their subjects complained that the latter were very fatiguing. Other experiments show colored lights to have no advantage over white light either for direct illumination or for background. Pressey experimented with blue, green, and red in various shades and brightnesses. He gave his subjects fifteen minutes' work with each hue, during which time he tested tapping rate, multiplication, association, memory, and speed in continuous reaction. No differential effects of the hues as such could be detected, but there was a decrease of efficiency under dim light. Of course, some colors give a dimmer light with the same strength of bulb.

Standards of illumination for industry and for schools have been worked out and are available. An example is the American Recommended Practice of School Lighting (1). Excellent discussions of problems of lighting are to be found in recent textbooks on applied and industrial psychology.

Visual defects, particularly the refractive defects which cut down visual acuity, lower efficiency considerably and in addition set up muscular tensions in the eyes which add to the nervous strain and fatigue of a day's work. The ease with which such defects can be remedied makes it imperative for mental workers and those who do close work to have them corrected. The majority of people suffer a steep decline in visual acuity for material held at ordinary reading distance when they pass 45 years of age. Acuity at greater distances may be as good as ever, but this is no help for close workers. Other factors in vision, such as ability to discriminate colors, to perceive depth, and to converge the eyes readily, may affect efficiency in special tasks but are not as generally important as acuity is. Color blindness, of which the most common form is weakness in the direction of red or green or both, cannot be corrected. Total color blindness is rare. All forms are much commoner among men than among women, the ratio being about ten to one. Ability to discriminate colors decreases with age, so that there is a fairly large fraction of the population who have reduced capacity, even though out-and-out color blindness is limited to about 5 per cent of the population.

Quiet conditions are ideal for mental work but are not often obtained in real life. Probably the effect of noise in creating nervous tension is more important than its effect on immediate efficiency in work, for it often fails to lower output appreciably. When a person has worked in noisy surroundings, a change to quiet conditions may prove more distracting than a change from quiet to noisy conditions. But the long-time nervous strain cannot safely be ignored, even though adaptation sets in after a time.

It will be remembered that Laird (14), in a study described on page 164, studied the energy expenditure of typists in noisy versus quiet conditions. He found that their working

metabolism showed a 20 per cent greater increase over the resting metabolism when they worked under noisy conditions for two hours than for a like period of work in quiet surroundings. Harmon (8) obtained similar results. In his study, he deliberately used random noises recorded on phonograph records in a busy office and on a noisy street corner. He found that the introduction of the noise at first retarded output, mainly affecting accuracy, but that as the subjects became accustomed to the noise the initial retardation was overcome. The energy cost as shown by increased metabolic rate, however, more than offset any positive gain.

In a more recent study than those already referred to in this and earlier chapters, Laird (13) compared the effect of variable and steady complex noises versus simple tones such as are produced by a tuning fork, varying in intensity from 48 to 90 decibels. He found that the variable complex noises had the most disruptive effect on work, the steady complex noises were next, and the simple tones had the smallest effect. High-pitched noises were the worst; any reduction in noise was accompanied by increased output. Unlike other investigators, he obtained no evidence indicating eventual adaptation, even after a 4.5-hour work period. The noise definitely increased the rate at which fatigue developed during the work period. The failure to discover any practice effect or adjustment to the distracter suggests that Laird's subjects must have taken a different attitude toward the situation than, for example, those of Morgan or Ford, mentioned in Chapter IX. Certainly the distracting noises in these two experiments were just as variable and just as complex as in Laird's.

Diurnal Variations in Efficiency

Everyone knows that his feelings and performance level vary within wide limits during the day. Some of these

changes seem to be related to such periods as mealtime, time of arising in the morning, and bedtime. It is also known that people who are ill feel better during certain parts of the day and worse during others; these periods seem to be fairly constant. If a person is running a fever, his temperature is lower in the morning and rises considerably in the late afternoon and evening. Are there any corresponding variations in efficiency level, particularly for mental tasks? To what extent can this be said to be constitutional and to what extent due to habit? Are there any obvious physiological changes which might be expected to influence the level of performance during the day? Can diurnal changes be looked upon merely as the effects of the accumulation of fatigue from a day's work?

The Diurnal Curve of Output.—It was originally assumed that there is a characteristic curve representing the course of efficiency during the waking hours for the average person, based on some constitutional factor. However, an examination of all the studies thus far made convinces us that no such typical curve exists. Rather, we must consider the age of the subjects, their occupation, and their own habits, particularly with reference to times of sleeping, eating, and peak loads of work demanded by the requirements of their job. For example, a careful experiment on school children by Gates (6) indicates a low point of efficiency for the whole day at the beginning, which was 9 A.M. From this low point there was a steady rise to a maximum at about 11:30 A.M. Thereafter, the course depended on the nature of the activity tested. Such mental activities as addition, completion, or multiplication showed a slight drop after 11:30; this continued until 1:00 P.M. when recovery set in. This carried the level of performance by 3:00 P.M. up close to the morning peak. On the other hand, memory tasks showed a steeper drop around noon and never recovered the lost ground dur-

ing the afternoon hours. Tasks involving speed and accuracy of movement gave a steadily rising efficiency curve throughout the day. But when accuracy was separated from speed, it showed the afternoon drop, indicating that quickness of movement is the only factor that improves throughout the day.

Compare with this the diurnal curves for adults. Earlier work reported by Marsh (16) seemed to agree with the children's curves; that is, for predominantly mental functions there was a low point at the beginning of the day, a rise until noon, a slump around mealtime, then a rise in the afternoon, and a drop in the late evening. On the other hand, tests of physical strength, speed of movement, and the like showed a steadily increasing efficiency throughout the day into late afternoon, then a subsequent drop. In contrast to this, Hollingworth (10) and Laird both report a high point in intellectual efficiency at the beginning of the day, around 8 A.M., and a steady decrement from then until 5 P.M. Laird (15) studied such functions as reading, comprehension, and recall in college students. He noted that, in the hours between 8:00 P.M. and 10:00 P.M., the subjects showed a secondary spurt, which can probably be accounted for in terms of the evening study habits of college students. Hollingworth agrees partially with Marsh and Gates in finding that speed of movement, as tested by tapping rate in this case, improves throughout the forenoon; but he fails to corroborate the continued rise during the afternoon hours.

To summarize the results for output, all the investigators agree fairly well in finding that quickness of movement rises from a low initial level in the early morning, but they disagree on the course of mental efficiency. Part of this disagreement can be attributed to the different routines followed, such as the late study hours of college students. Does this account for all of it? To answer this, it is necessary to in-

quire into what has been found out concerning the physiological side.

Diurnal Curves of Bodily Condition.—Marsh (16) has summarized the early studies of heart rate, blood pressure, temperature, and breathing rate. All of these increase during the day from an early-morning minimum. Freeman measured energy consumption each hour by weighing the subject on a delicately poised balance that was sensitive to as little as one-tenth of a gram change in body weight; thus he obtained an index of the insensible weight loss through perspiration. He found that, when such factors as time and amount of sleep, eating, and activity were kept constant, the diurnal variations remained fairly uniform. When two persons observed the same daily regimen in respect to the above factors, their diurnal curves were very similar; this applied to their performance curves as well as to energy expenditure. But a change in the time of eating or sleeping caused corresponding changes in the curves; the reversal of the day and night regimen produced a corresponding reversal in the curves. All this points very strongly to the relativity of the whole process of diurnal variation. Incidentally, it indicates that the difficulty experienced by persons in changing from day to night work is not based on any violation of a basic physiological law, but is merely the difficulty that is found in reversing any set of well-established habits.

In this connection, there is a probable explanation, in the diurnal tonus variations, for the low level of efficiency in speed of movement in the early morning and the steady rise during the day. Travis (18) obtained measures of muscular tonus at regular intervals from the hour of rising until retirement at night. He found that tonus is at a minimum on rising and that it increases from that time on until ten o'clock at night. We know that quickness of reaction de-

pends on the muscular preparedness, the attentive set, of the reactor. It is not strange, therefore, to find complete agreement between the diurnal variations in tonus and the curve of efficiency in speed of response.

The general conclusions to be drawn from these studies can be put in the form of principles for our guidance, as follows:

There are no fundamental unalterable bodily rhythms which set the course of diurnal efficiency.

People have acquired different habits of sleep, eating, and activity which give each individual a more or less characteristic diurnal pattern.

This learned pattern determines not only the periods of high and low efficiency but also the supporting bodily rhythms.

Any such individual pattern can be changed by learning a new set of habits.

To achieve maximum efficiency, each one should decide which pattern fits best the demands of his workday, and then follow it until it has been thoroughly fixed by habit.

Weekly Curves of Efficiency

The seven-day week, with its five and a half consecutive days of work followed by a day and a half of holiday, is a purely arbitrary cycle; hence we should hardly look for any organic basis for a universal weekly efficiency curve. We would rather expect to find that if there are any typical variational trends during the week, they are determined by the habits of the particular culture to which a person belongs. We would expect to find one type of efficiency curve for Russian workmen, who have no Sunday holiday and whose week differs in length from ours, and an entirely different curve for American workmen. We would expect to find one

type of curve for students and another for office workers. Nevertheless, for a given group, we should expect to find considerable correspondence for all its members. So the questions we are led to ask are, first, whether there is any decided trend in the weekly output curve and, second, what factors determine it.

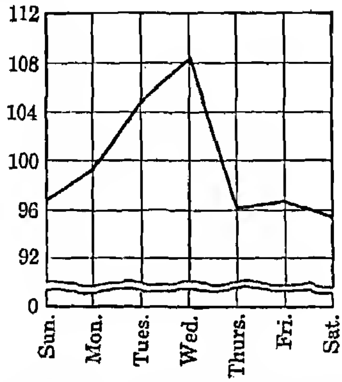

FIG. 15.—Average performance curve for a week, showing the composite day-to-day output on several mental tasks. (From D. A. Laird, in *J. Exper. Psychol.,* 1925, 8, 57.)

One of the best available studies was made by Laird (15) on college students. He obtained records of the average performance level of 112 students for each day of the week in the following mental tasks: comprehension, code substitution, reading, memory for words and ideas, and addition of figures. The resulting curve, which is reproduced in Fig. 15, shows each day's performance level as a percentage of the week's average level which was considered as 100 per cent. When the curves for each task are plotted separately, they show considerable variation. For example, the curve for comprehension reaches its maximum score of 114 on Monday and decreases thereafter every day to Sunday. The addition curve reaches a maximum on Tuesday. All the other

curves have their high point on Wednesday. Memory shows the widest fluctuation of all, with a Monday low of 88 and a Wednesday high of 122. Fig 15 shows the average curve for all tasks and can be considered a representative weekly curve for students. It is characterized by a rise from 97 on Monday to 109 on Wednesday, then a sharp decline to 96 on Thursday, and a fairly steady level from there on.

Industrial curves, as worked out principally by English and German psychologists, show similar tendencies. The English curve commences at a low level on Monday, rises during Tuesday and Wednesday, reaches a peak at midweek, then drops sharply Thursday, and recovers partially during Friday and Saturday. The Italian curve, on the other hand, has no Wednesday peak but shows a decline during the latter part of the week with no Friday-Saturday recovery.

What factors determine the differences in these group results? One is the length of the workday. When a longer workday has been adopted to increase production during war time, the results have been so disastrous that the responsible officials have quickly returned to the pre-war schedule. It can easily be imagined that, with a longer day, the accumulation of fatigue would be great enough by the latter part of the week to prevent any Friday-Saturday recovery. Hence the advantage to production that is gained from a longer day is lost by the slump late in the week. In the case of the student curve, the high peak at midweek and the week-end slump can easily be accounted for by habits of the distribution of study and social activities. The student begins to look forward to week-end social activities before Friday; he has hardly recovered from them by Monday. Even for persons of more mature habits, there is something decidedly uneconomical about the five and one-half day week. If we considered the weekly curve as a long work curve, then the rise from Monday to Wednesday would constitute a warm-

ing-up period, and the slump thereafter would correspond to the fatigue decrement. The most economical time for a rest is just after the peak efficiency has been reached, before the slump has carried productivity below the optimum range. Thursday is the natural point at which to introduce a half-day rest. Therefore we herewith advocate that all workers, particularly mental workers, adopt such a plan. Housemaids already observe the Thursday half holiday; why not office workers, industrial workers, business men, and students?

With the work week as it is, what practical lessons can we draw from the efficiency curve? First, that in planning the week's tasks, either for oneself or for persons whose work one supervises, arrangement should be made for the most important, most exacting, or heaviest tasks to be done during the early or middle part of the week; the latter part should be used for less exacting work. Secondly, definite steps must be taken along the line of extra stimulation, arousal of interest, etc., to overcome the initial lag in getting under way on Monday. Finally, if at all possible, the tendency to concentrate recreational activities into the week-end should be replaced by a rational distribution which allows a midweek breathing spell, even if it is only an evening of complete bodily and mental relaxation.

Other Periodic Variations in Efficiency

Superimposed on the weekly rhythms are still longer periodicities. One of these is the type reported by Hersey (9), who studied periodic variations in feeling-tone and found cycles whose average period was from 3 to 9 weeks, varying from individual to individual. These cycles show a range of feeling-tone all the way from elation to depression,

and they seem to affect productivity in a comparable manner, although the correlation is not close. Hersey suggests that they may have an organic basis, in both men and women, for it is believed that men also pass through a periodic type of physiological change. Unlike these internally determined periods, seasonal variations seem to be dictated by the prevailing weather and atmospheric conditions during each of the four seasons. Thus Peaks (17), who brought together a large amount of evidence on seasonal changes in mental output, attributes them to such factors as temperature, strength of light, humidity, body temperature, and the kind of food and clothing. The most striking characteristic of Peaks' data is the depression during the winter months. Most people find that summer marks a low point in intellectual productivity. Autumn and spring seem to be the seasons of accomplishment. It will be remembered that Kleitman (12) found autumn to be the period when sleep was most free of dreaming; temperature conditions are moderate, and the relief from the summer heat improves feeling-tone and restores nervous energy.

What of the day-to-day swings in weather conditions; do they affect our efficiency level to any extent? The effect could hardly be a direct physiological one because we work in heated rooms whose temperature is independent of the outside weather. But there might be an indirect effect on our mood, and this is in fact true. A number of people were asked to rate their mood each day and these ratings were compared with the prevailing weather conditions. A cheerful mood was found to prevail on bright, pleasant days, and various degrees of depression on dark, disagreeable days. These moods did not appear to have any great effect on the performance of simple routine mental tasks; but they might considerably influence a person's effectiveness in tasks re-

quiring a higher level of initiative and spontaneity of action. Effectiveness in dealing with other people might depend crucially on such alterations of mood.

Atmospheric Conditions

Of the three major factors, humidity, barometric pressure, and temperature, barometric pressure has proved most important. When the barometer rises, nervousness and irritability increase and ability to concentrate declines.

How important are conditions of ventilation in the rooms where work is done? Strangely, some factors, which are commonly thought to be important, do not prove important under test conditions. Temperature alone can be raised to 86 degrees without seriously affecting efficiency; but when humidity is raised at the same time to around 80 per cent, the inclination to do mental work is greatly reduced. Of course, physical workers are even more sensitive to such extremes. Weston (19) reports a rise and fall of roughly one per cent in productivity in the linen-weaving industry for each degree of rise and fall in wet-bulb temperature. If the air is kept in circulation, much of the detrimental effect of heat, humidity, and staleness can be overcome because the circulation of the air removes the discomfort that arises from the body's inability to regulate its own temperature by evaporation.

Does the goodness of air depend on its oxygen content? How about the person who fears to stay any length of time in an overcrowded room, on the assumption that the oxygen content of the air will become dangerously reduced? What of the argument forever being waged between those who want the windows kept open to get "pure" air, and those who want them kept closed for comfort? On the basis of experimental evidence, such as that obtained in experiments

in special breathing chambers in the interests of high-altitude flying, mental processes are not appreciably retarded when the oxygen content of the air breathed is reduced to 12 per cent, or slightly over half the normal oxygen content. Beyond this there is a rapid reduction in efficiency, particularly in accuracy, until, when the oxygen content is between 8 and 10 per cent, memory becomes greatly weakened, associations cease to be formed, emotional control is lost and fits of anger or silly laughter are common, judgment is defective, and sustained attention is impossible so that commands have to be given repeatedly in a loud voice. A further reduction to 6 per cent causes loss of consciousness in most persons. More than a few minutes without any oxygen would do irreparable damage to the nervous system. Mountain climbers who ascend to great heights where the rarefied atmosphere makes it difficult to obtain enough oxygen, experience dizziness, headache, shortness of breath, and a tendency toward sleepiness, lethargy, and exhaustion from the least exertion at heights in excess of 15,000 feet.

Although interesting to know, these facts have slight bearing on ordinary ventilation problems because the usual stale air in crowded rooms contains enough oxygen to support normal mental activity. The oxygen content never goes below 16 per cent. The sleepiness and discomfort experienced probably result from other factors. Twenty cubic feet of air contains enough oxygen to supply one person for an hour or two; a small room has from fifty to one hundred times this much air. Persons entering a crowded room immediately notice the stale odor, but those who have been in it continuously do not, because they have already adapted to it and their sense of smell is no longer affected by it. The sense of smell adapts more rapidly than any other sense, so that all but the stronger odors are selected out and cease to be smelled after fifteen minutes' continuous exposure to them.

This is not intended as an argument for keeping windows closed; it is merely reassurance to those who have an excessive fear of crowded or stuffy places. Actually temperature, circulation, and humidity are more important factors because they affect the comfort of the worker and react on his satisfaction and willingness to work. Of course, improper clothing can exaggerate poor ventilation. Most of us, especially the men, wear too much and too tight clothing.

What are the ideal conditions of ventilation? A temperature of about 68 degrees for mental work, lower for physical; a humidity of about 50 per cent, because greater amounts retard mental efficiency and amounts below this have a long-time effect in drying the nasal passages and promoting colds; moving rather than stagnant air, with a normal oxygen content; and light, loose-fitting clothing for inside work.

Diet and Stimulants

Little need be said in these diet-conscious days about the importance of an adequate intake of food, well balanced as to the various food values, minerals, and vitamins. Such matters are best left to medical advice because of the varied demands of the individual constitution. On the psychological side, a great deal is known about the effects of diet on mental efficiency and energy. The extreme case is that in which a person goes on a protracted fast. The belief somehow was initiated that fasting improves the power to think and that the products of thought are of a higher type. Experiment gives no basis for this notion. Thus Glaze (7) worked with three subjects, one of whom fasted 33 days, one 17, and one 10. They were tested for a long time before and after the actual fast period, so that the total experimental periods were 110, 82, and 77 days. The tasks included mental multiplication, perceptual speed, and tests of sensory acuity. The

characteristic effect during the actual fasting period was a deterioration in performance, the severity depending on the length of the fast. However, this was not a permanent slump because, when the fast was over, there was a decided spurt in efficiency. Those who have tried partial fasts—that is, a restricted food intake for a time—also report some loss in intellectual acuity and in quickness of reaction, great muscular weakness, and feelings of incapacity and discomfort. Fasting a single day produces no changes in performance distinguishable from ordinary days. All the results point to the conclusion that the brain, like the rest of the body, requires adequate nourishment but does not lose efficiency quite so rapidly under an inadequate diet as the muscles do. On the other hand, overeating is decidedly detrimental to a mental worker because of the demands it makes upon the organism's energies to carry on digestive processes. Many persons experience dullness and unwillingness to do strenuous intellectual work after a heavy meal. This works both ways, for doing exciting or exacting mental activity on a full stomach can delay or interfere with the digestion of food. The conclusion is that daytime mental workers should eat light lunches and delay their heavy meal until evening; those who work at night should reverse this program.

Another subject on which much false information exists is the nature of the action of such agents as alcohol, tobacco, and coffee. Alcohol is often, but falsely, called a stimulant. The argument for this runs somewhat as follows: "Small amounts of alcohol increase a person's confidence, raise his spirits, loosen up his ideas, stimulate his associations, and remove the hampering inhibitions that ordinarily interfere with complete self-expression." Yet all the experimental evidence points to the classification of alcohol as a depressant rather than a stimulant, both physically and mentally. Sensory acuity is dulled, muscular reactions are retarded, and

all such thought processes as memory, learning ability, and even routine controlled associations are slowed. How can we account for the discrepancy between the popular notion and the experimental facts? The answer lies in the way alcohol acts on the nervous system. It attacks the highest centers first, dulling judgment and the fine sensibilities. The result is that a person is deceived as to his own performance, thinking it better than it is; this gives him the self-confidence and volubility that create a false impression in others who observe him and convince them that he is mentally more alive. The chief disadvantage of alcohol, aside from its habit-forming possibilities, is that it belongs to the group of drugs which have a delayed effect, a hangover, in which all feelings of buoyancy disappear, to be followed by mental depression and emotional irritability.

Tobacco has a more ambiguous effect than alcohol. It has a slight temporary stimulating action which relieves feelings of muscular fatigue and slightly speeds up such processes as adding. On the debit side of the ledger, it causes a reduction in memory and in accuracy, and interferes with all the fine motor skills by increasing tremor in the hands. Any effects of smoking are more marked in occasional smokers than in habitual users.

Of all the so-called stimulants, caffeine, the chief drug in coffee and tea, really lives up to its reputation. Hollingworth made a follow-up study of the effects of doses equivalent to from one to three cups of coffee for as long as seventy-two hours after taking. His subjects submitted to a carefully controlled regimen of work, food, and rest during the experiment. The following points were reliably established:

1. The effects appear within an hour and last from three to twenty-four hours. No subsequent depression appears within seventy-two hours, and no bad cumulative effects were found within a forty-day period.

2. There is some loss of muscular steadiness, and an increase of tremor, especially with large doses.

3. The pulse is accelerated.

4. Speed and accuracy in routine mental operations are increased.

5. In many people sleep is seriously disturbed by large doses, but not by the average amounts imbibed.

In general then, coffee or tea in reasonable amounts is a stimulant which can safely be taken by people who feel the need of a pickup during work or at meals, with the assurance that no compensatory depression will follow. The only feature about caffeine that calls for hesitation is the fact that it causes wakefulness in some persons and is slightly habit-forming so that its omission causes symptoms like headache and nervousness in habitual users.

In recent years certain other stimulating drugs, such as benzedrine sulfate, have been popularized. This drug, which is somewhat like adrenalin in its action, is an anti-hypnotic; i.e., it causes the person who uses it to be wakeful, and counteracts all tendencies toward drowsiness. By taking the proper dose every four hours, certain scientists have been able to keep themselves awake for several days, without any desire for sleep. However, the long-time effects of insomnia are so little known that this procedure is dangerous for the layman. College students began using this drug as a means of staying awake while cramming for final examinations. Not only does benzedrine sulfate counteract drowsiness, it gives relief from feelings of fatigue. Physiologically it has the effect of raising the blood pressure, but only in doses of 20 mg. or more.

Barmack (2) studied the effects of small doses—10 mg.—as compared with a control dose of blank pills, on 36 subjects engaged in addition problems for two hours. He noted a slight benefit in delaying the objective decrement in the

work curve, but he concluded that "the effect of Benzedrine under the conditions studied is not principally on the ability but on the inclination to do continuous repetitive work." Another series of investigations, carried on by Carl and Turner (3) at the Institute of the Pennsylvania Hospital, points in a similar direction. They find that moderate doses accelerate reaction in "psychomotor tests" not requiring deliberation, but that heavier doses, such as 20 to 30 mg., cause a retardation which appears thirty minutes after the dose and persists for about forty-five minutes. Strictly mental functions, like memory and analytical thinking, are not benefited by moderate doses and are confused by heavier doses, until the effect of the dose wears off. Accuracy is not affected, except that it is decreased by heavy doses. All effects tend to wear off after three hours or more. The authors report "a generally favorable reaction in mood, feeling-tone, or affective attitude, and this reaction, in combination with various degrees of stimulation in a physiological sense, favors performance in tasks which call for alertness, persistence, and freedom from fatigue."

Summary

In this chapter a number of environmental and physical conditions have been shown to influence efficiency in mental work. Among those whose precise effects were discussed are:

The sensory conditions in the work environment, particularly illumination and noise.

The diurnal pattern of high and low productivity which seems to repeat itself day after day, but depends on habit rather than constitution.

The analogous weekly pattern and the longer swings covering weeks and even months from peak to trough, that probably depend on mood changes.

The state of the weather and the inside conditions of ventilation and atmosphere.

The mental effects of diet and of the commoner so-called stimulating drugs, of which only caffeine and benzedrine sulfate merit the name.

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Chapter XIV

GAINING EFFICIENCY THROUGH LEARNING

Most of the things we do in a day's work are performed with about one-quarter to one-half of the efficiency we might use. This is a very conservative estimate. Probably we do many things with only one-tenth of the skill possible. In fact, we often have an excellent opportunity to judge how far below par our own performance is in a given skill by comparing it with the performance of an expert in the field. The contrast convinces us that we have plenty of room for improvement. But in many cases we have been doing that act just as long as the expert has. Why are we so poor at it, and why is he so good? The main difference between the expert and the mediocre performer is that the expert deliberately sets a high goal for himself and then practices with the definite intention of reaching it. He learns with the conscious purpose of improving. Therefore he adds to his skill every time he does the act. He attends to every motion he makes, judging it critically and deciding how it can be made more perfect. The mediocre performer, on the other hand, fails to improve because he leaves the matter of improvement to chance. Mere repetition of an act without a determination to improve rarely results in improvement. Why does the average person hesitate to embark on a formal program of improvement through systematic learning? Let us list some bad reasons and then, after refuting them, some good reasons.

Why We Hesitate to Improve Through Learning

We Lack Confidence in Our Ability.—Many persons are deterred from any attempt to perfect themselves through

learning because they feel that they lack talent. It is true that there are wide differences in initial ability; there is no point in minimizing them. But it is also true that most people possess enough native ability to learn many acts of skill well. And it is also true that many of the experts are just ordinary persons with average ability; often they are actually handicapped initially in the very direction of their skill. An outstanding example of this is the former aquatic champion, Annette Kellerman, who had to overcome a spinal curvature and ill health. Therefore the lack of initial ability is a poor reason to give for failing to do things well.

We Lack Ambition or Energy.—There is a little more point in the lack of ambition or energy, because no one has enough energy to do everything well even if he has the ambition. In fact, it would be a queer ambition to want to be an expert in everything. We have to concentrate on essential things and neglect unessential ones. First come the skills directly associated with our vocation; whatever time and energy remain are available for developing and perfecting skills in the direction of our favorite hobbies. Even so, the fact remains that most of us are far from the experts we might be, even in the few things we would like and ought to do well. So this reason for not trying to improve by learning—the plea that we lack energy—is at least half bad.

We Lack Time.—Of all the reasons that could be offered, the lack of time is about the weakest because it presupposes that learning in order to improve in a performance is something which requires extra time outside of the round of daily chores. This is a false notion. Learning with the idea of becoming expert is merely a changed attitude toward the performance of the act; it is not a matter of undertaking a great deal of extra practice or of embarking on an elaborate educational program outside of regular hours. It is mainly a question of adopting a conscious set to improve from day to day.

Not only does it often require no more time than we ordinarily devote to the performance of the act, but, as we improve in it, there is an ever greater saving in time and energy. Consider a concrete example. A certain person who earns his living by writing has such illegible handwriting that he is forced to write his articles on a typewriter. But he typewrites very slowly because he uses the "hunt and peck" system instead of the touch system. He also suffers from headaches because he must watch the keyboard and the paper at the same time; this strains his eye muscles. He has been doing this for ten years. The time required by the average person to learn the touch system is a few months at most. Yet this man goes on, year after year, working at half efficiency because of his inertia or his lack of confidence in his ability to learn the superior skill.

We Think We Are Too Old.—One of the chief factors that holds many persons back and prevents them from realizing their potentialities to a greater degree through learning, is the totally erroneous idea that learning is something we do in school, and that adults lose the capacity to learn. This is an extremely bad reason. The most recent evidence from studies of the rates of learning in adults shows that there is a steady improvement up to age 20; from then on, learning ability holds its own until age 35 or 40, after which the decline is fairly slow until age 55 or 60. In addition, adults have many advantages over younger people, such as greater stability of purpose, more practical experience to give point to what they learn, and more mature judgment. Most of the hesitation on the part of adults to learn new things or to perfect old skills is the fear of taking the initial plunge, breaking the intellectual ice.

We Cannot Learn Everything.—Now for some good reasons. It is right that we should use some discretion in selecting the things in which to perfect ourselves. No man

can be an expert in every field. Part of the advantage gained from learning and practice is the fact that we learn to concentrate on essentials and to shut out unessentials. The first step is to select carefully. There was a feeble-minded boy who could name the day of the week for any date that his questioner mentioned, over a period of several years. Thus, if he was asked, "What day of the week was the seventh of September, 1923?" he was ready at once with the correct answer. Another of his accomplishments was remembering the numbers of all the freight cars that had passed his home in several years. Remarkable! you say. Yes, but how utterly worthless! No one but a moron would have put forth the effort to learn this type of material.

We Should Consider Our Limitations.—The first step, then, is to choose a reasonable group of skills or habits and then to set about perfecting them in a thoroughly businesslike way. In this, certain limitations of age and talent must be considered. While learning ability does not decline until late middle age, the ability to do acts requiring muscular agility and quickness does decline. If a person is slow at figures, he would be ill advised to try to become a certified public accountant. A person who stutters would waste time trying to perfect his skill in salesmanship.

The Process of Economical Learning

Let us suppose that we have selected a certain job, skill, body of specialized knowledge, or habit which we wish to perfect. Can we depend on automatically improving by merely practicing the habit, repeating it over and over? No; repetition alone never improves an act. There are certain conditions for doing the repetitions that are necessary to insure improvement. A man may write with a pen every day of

his life, yet his penmanship may steadily deteriorate. What are the added factors that are essential?

Accurate Observation.—We must first make accurate observations. If it is an act of skill that is to be learned, we must have accurate knowledge as to just how the act should be performed, either by watching an expert, by making accurate observations of the necessary steps in doing it, or by securing information about it from a book. If it is a body of knowledge to be learned, half the battle is won by making sure that we learn the right things and learn them correctly. It is as easy to remember correct information as incorrect; there is no more tax on the brain. Yet two-thirds of the mistakes made by students on tests are due to learning the wrong things or learning the right things wrongly, rather than to failure of memory. They failed to make the initial accurate observations.

Organizing for Effective Learning.—One great mistake made by learners is the assumption that a thing should be learned in the form in which it is presented. This is not true. Most things, whether acts of skill, fields of knowledge, or jobs, require reorganizing for effective learning, in accordance with the plan of arrangement best suited to the individual's type of thinking. In the process of reorganizing, we often throw out irrelevant things and boil down the remainder to the quintessence of facts or steps. We rearrange it in the order in which we expect to use it. The particular order is less important than the fact of having *some order* which we ourselves have imposed on the material. For example, a student of pharmacy had to commit to memory several hundred doses of drugs, with the exact amount of each drug in minims. The book he studied presented them on the basis of the size of the dose. Obviously this would be of little practical value to him after he became a druggist. He had to re-

arrange this material in the form in which it would be most useful later on and, in so doing, he advanced his learning by the process of rearrangement itself.

Economy in Fixating a Habit.—The actual procedure of perfecting a habit involves repetition, but whether or not the repetition is actually effective in producing improvement or learning depends on how it is carried out. The following are a few good rules in this connection:

Space Your Learning Effort.—Don't try to learn all at once. This leads to discouragement and is uneconomical, because the brain becomes fagged and does not retain things as well. Experiments show that an hour's daily practice spread over six days is better than twelve hours of practice in one day. There is no advantage in hurrying the learning process.

We Learn Best by Using.—Just as soon as something has been learned, it should be put to immediate use to fix it. There are several reasons for this. One is that the nervous system is so organized that the connections we wish to make cannot be completely formed until we have actually gone through the act. Another is that by performing the act, even if this consists merely in reciting the material to ourselves, we make mistakes. This emphasizes what we don't know and enables us to concentrate on those particular parts and master them. We are given a mild punishment by the annoyance caused in making the mistake, and this helps to stamp out the incorrect acts. At the same time we receive a reward in the form of a glow of pride or satisfaction when we perform correctly, and this results in fixing the correct acts. Psychologists attribute these results of success and failure to a fundamental law of learning, the law of effect. So important is it to put immediately to use what we learn that in the case of material memorized from a book, it has been found that only one-fifth of the learning time should be devoted to

reading; the other four-fifths should be used for reciting or reproducing what has been read.

Study Your Learning Curve.—It is highly important for the learner to keep close track of his progress for several reasons. One reason is the stimulating effect of knowing one's past record and trying to beat it; it is almost as much of an energizer as competing with some other person. Another reason is that such a record immediately shows the effect of any change in method and indicates whether the change is for the better or worse. Finally, it indicates when the limits of

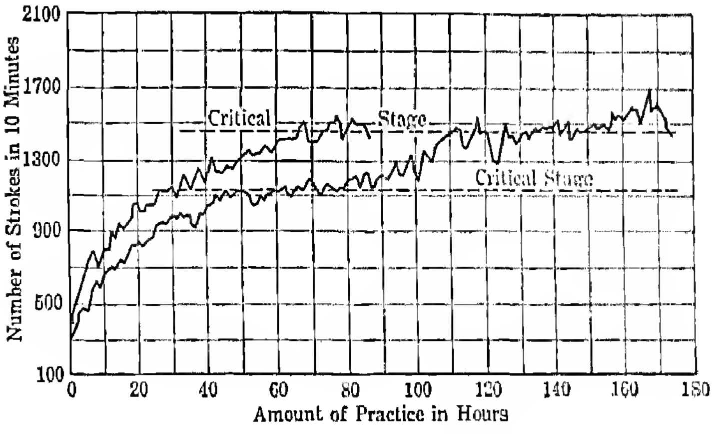

Fig. 16.—Learning curves for acquiring typewriting. (From W. F. Book, *Learning to Typewrite*, Gregg Publishing Co.)

The learning curves show the progress of two individuals in learning to typewrite by the sight method. The first subject (lower line) makes rapid improvement at first, but reaches a first plateau after 40 hours of practice and does not improve again in rate until after the 80th hour. A second plateau occurs from the 110th to the 155th hour of practice. A second subject (upper line) stays on the first plateau for a very short time, but remains on the second plateau from the 60th hour onward. The plateaus are most probably due to the acquisition of inefficient habits that must be overcome before further increase in speed is possible. The small irregularities are due to day-to-day variations in efficiency.

learning are being reached. The best way to keep track of progress is to plot a rough curve of progress, called a learning curve. By way of illustration, two such learning curves are shown in Fig. 16. The upper curve, which represents one subject's rate of progress in learning to typewrite (2), indicates the amount of improvement that took place during ninety practice days. The learner spent one hour a day in practicing, so each day of practice represents an equal amount. The horizontal base line is divided into nine periods of twenty days' practice each. The vertical axis to the left indicates the number of letters typed during a ten-minute period on each of the ninety days. Thus it can be seen that on the third day of the practice period the learner could type only 500 letters in ten minutes. By the twentieth day, this had risen to about 1050, and by the eighty-third day to 1500 letters.

Several points should be noticed with regard to this curve, since it is typical of all curves for learning acts of skill. The greatest progress occurs in the early stages of practice; later there is a slowing down in the rate of improvement. It is important to know this. Beginners often surprise themselves with the rapid strides they make in the first few trials. Later they are conscious of slowing down and they become discouraged, thinking they are wasting time and not progressing. Actually this is an almost universal feature of learning curves. It does not indicate failure; it is what is to be logically expected. At first, performance is so far from perfect that improvement is an easy matter; but, as they gain more skill, beginners approach nearer to perfection and it becomes harder and harder to beat their past record. It is the good learner, the real expert, who sticks to it when the going gets really hard and, at a greatly increased expenditure of effort, finally achieves a high point of efficiency that is the envy of those who stop trying at a lower stage.

The Plateau.—It frequently happens that a person reaches a point in the learning curve where he fails to advance at all for weeks or even months. This is known as a plateau. The lower curve in Fig. 16 contains a plateau. It is the most discouraging period of all, because the learner naturally assumes that he has reached the limits of improvement. If he perseveres, however, he is rewarded by a later spurt of improvement which carries him far above the level of the plateau. This shows that the plateau was not a period of wasted time but was really a necessary period of consolidation of what had already been learned. The later spurt of progress could not have appeared without it. Sometimes more than one plateau may occur in a total learning curve; some of them may indicate periods when the initial enthusiasm has worn off. They last until the lost enthusiasm has been replaced by voluntary effort and determination, or until new enthusiasm has developed.

Day-to-day Fluctuations.—Every learning curve shows day-to-day ups and downs which should not be regarded too seriously because they are caused by temporary factors. For example, in the figure the level of performance on the 68th day is about 1530 letters in ten minutes, whereas on the 69th day it is only 1390. This slump is quickly recovered from, and a new high is reached by the 77th day.

Warming Up.—Sometimes learners find that, in learning something new, considerable time is wasted before getting under way. This is a species of warming-up time, a period of getting down to business. It is a rather discouraging stage and often acts as a wet blanket, leading the learner to give up before he has had a taste of the success that is sure to follow.

Other Criteria of Learning.—The curve in the figure is known as a "rate" curve because it indicates an increase in the number of units of work done in successive units of

time. But sometimes accuracy is more important than speed. In this case the vertical axis can represent errors instead of the amount done, and the learning curve will show the rate of improvement in accuracy. Sometimes the improvement resulting from learning is apparent mainly in reducing the amount of effort necessary to perform the act. Well-practiced acts usually require less effort. If we wish to study the effect of practice in reducing effort, we represent degrees of effort along the vertical axis, and successive trials on the base line. Effort can be measured in at least three different ways. It can be estimated in terms of a subjective scale of feelings of ease or difficulty of performance. It can be judged by the amount of unnecessary tension and useless movements accompanying the act. Finally, if the necessary apparatus is available, it can be determined in terms of some physiological measure of energy expenditure. For example, Rounds, Schubert, and Poffenberger (4) used the "respiratory calorimetry" method. The task was the adding of three-place figures; it was practiced daily over a number of weeks. The total practice gain was 46.7 per cent of the initial level of performance. That is, the average number of problems solved in the first five days was 24.2, and in the last five days 35.8. The saving in energy was computed on the basis of the decrease in average net oxygen consumption per problem solved. This showed a drop from 61.0 cc. during the first five days to 31.6 cc. during the last five days, or a total saving of 48.2 per cent. These investigators thus demonstrated that the metabolic cost of performing a partially learned task is far greater than that involved in doing a well-practiced one.

Speed versus Accuracy.—The tendency of learners is to stress accuracy in the early stages of learning a skilled act and to emphasize speed later. This seems a sensible procedure, especially in complex skills where accuracy is more important. But it is not always the best way. Bird (1) has pre-

sented evidence that a slower speed than normal is just as productive of errors in tasks like typing and shorthand as too rapid a rate. Windmöller (5) found that the results of stressing accuracy or speed vary with the complexity of the task. His subjects worked on a variety of activities, such as typesetting, cancelation, addition, copying figures, and the like. All the tasks were performed under three different instructions: to work as fast as possible, to work as accurately as possible, to stress both at the same time. The results showed that emphasizing accuracy in simple tasks cuts down speed without benefiting accuracy. Complex tasks that require close attention to details benefit from accuracy instructions; it is detrimental to stress speed. But great differences exist from individual to individual in their responsiveness to speed or accuracy instructions. Both the fastest and slowest persons are likely to be the most inaccurate. The best advice to the learner is to decide what he wishes finally to achieve—a high degree of speed or a high degree of accuracy—and then to stress this throughout.

Breaking Undesirable Habits

A large part of the improvement in doing a complex task like typewriting may be due to the substitution of correct ways of doing things for the incorrect ways which have been learned originally. Therefore, learning is as much a matter of breaking habits as it is of making them. But breaking habits is a much harder process because of the psychological principle of negative transfer which always operates in this case. It is much easier for a person who has never learned to type to learn the touch system than it is for one who is already proficient in the "hunt and peck" system. This is so because strong associative bonds leading to the wrong kinds of responses have been established in the brain, and these bonds

must be broken or greatly weakened before the correct associative bonds can replace them. However, certain rules of procedure can be suggested which will greatly facilitate the process.

Attend to the Correct, not the Incorrect Habit.—One of the worst mistakes made by people who are trying to break an undesirable habit is keeping their attention directed to the wrong response. They are so fearful of making the wrong response that their attention is irresistibly drawn in that direction, and they concentrate on the very thing they are trying to avoid. This almost inevitably leads to making the wrong response. Attention should be directed exclusively to the correct response. A person who attempts to get rid of an undesirable habit without replacing it with an alternative habit is doomed to failure; there will be nothing to redirect his attention toward, so that it can be directed away from the wrong act. For example, a person learning to play golf should never try to avoid a sand trap by directing his attention to it; he should attend exclusively to a point beyond or to the side of it. This is not easy. It takes a distinct effort to blot out even the thought of the trap. But if it can be accomplished, the correct response is almost guaranteed. Most persons can walk a narrow plank without losing their equilibrium if it is placed on the ground, but few can do it if the plank is strung between two poles high in the air. The reason is that in the latter case their attention is irresistibly drawn to the ground far below them, and away from the plank that they are trying to walk. If they could completely ignore everything but the plank, they could walk it as easily as when it is on the ground. Therefore, in learning a correct act which is to replace an incorrect one, we should allow the wrong response to languish from sheer neglect, and give complete attention to the fixation of the right one.

Make the Performance of the Wrong Habit Unpleasant.—

There is one exception to the rule set forth in the preceding paragraph. When the performance of an incorrect act is made so unpleasant, futile, or actually painful that it becomes intolerable, then the oftener a person is forced to do it, the sooner he will break the habit. One cure which has been found successful in dealing with the alcohol habit is to mix some disagreeable-tasting stuff with the drink and let the patient drink as much as he can. The more he drinks, the sooner he will be cured. Dunlap (3) found that he could break certain habits like nail biting, stuttering, finger sucking, and the like, by compelling the patient to perform the act over and over again. Obviously, repeating an act under these conditions is disagreeable because it is not done spontaneously but is forced. Attention is directed away from the wrong act by sheer boredom. Dunlap interprets his success in a different way. He feels that this method enables the patient to become completely conscious of how it feels to perform the wrong act, so that he gains a voluntary mastery over it. This may be true in some cases; ordinarily, however, when a stutterer, for example, directs his attention to the act of stuttering, he stutters much more severely.

How to Retain What We Have Learned

Everything that has been said in the chapter thus far has related to the learning or fixating of habits. Many persons find that their greatest difficulty is not in learning but in retaining what they learn, at least for any length of time. The problem is somewhat confused because we think of retaining as an active process, something we must *do*. Of course the active process is not retaining but forgetting. Therefore we should ask why we forget, rather than why we do not retain. Below are several causes of forgetting; by avoiding them, we can improve retention considerably.

Associative Interference.—There is a popular belief that forgetting is caused by the mere passive fading out of impressions or habits with the passage of time. This is not true. Old people remember things that happened in their childhood very well, although many years have elapsed between learning and recall. Forgetting is not mere fading out. It is an active disruptive process in which bonds formed in learning are broken. If the brain is not used for other mental activities between learning and recall, the recall is perfect. For example, if we learn something immediately before going to sleep, we will retain it almost perfectly eight hours later when we awake, because the brain has not been used for any other purpose in the meantime. But if we learn something in the morning, eight hours later most of it is gone. The disruptive effect of what we have done during the day explains the forgetting. If the activities engaged in are very similar to the habit we are trying to retain, the disruptive effect is much more severe. For example, if after studying French we study Italian and later try to recall the French, we will experience great difficulty in recalling. But if we follow the French study hour with some very dissimilar activity, even though it is difficult, like doing problems in mathematics, the disruptive effect on the French will be far less.

Change of Setting.—The next most important cause of forgetting is the change which occurs in the stimulus situation between learning and recall. Since we remember things by associating them with other things present at the time of learning, we recall best when all these associated things are present at the time of recall. Thus we recall things best in their familiar setting. Experiments show that when we are in one room and we try to recall something that was learned in another room, some forgetting results. Also, if we learn a fact in a certain connection and are asked to recall it in a different connection, we experience difficulty. For example,

a person may learn to recite the Presidents of the United States in sequence, from Washington down, without error. But if he is asked whether the Monroe Doctrine was established before Andrew Jackson was President, he is unable to answer, even though the answer is self-evident from the sequence of the Presidents. The way to avoid this difficulty is to learn facts by connecting them with other facts in as many ways as possible, not in just one way. The more associations we form with the thing we are trying to remember, the more surely will the correct association operate at the time we wish to use what we have learned.

Under-Learning.—We often blame our memory, that is, our power of retention, for the fact that we forget things, when the truth is that we failed to learn them thoroughly in the first place. If ten repetitions of a habit or fact are necessary to learn it well enough for immediate recall, twenty repetitions may be necessary to fixate it for recall a month later; for permanent retention, perhaps thirty repetitions may be required. Ability to recall immediately is no criterion of adequate learning.

Lack of Review.—No matter how well we learn a thing at first, we will forget it soon enough if we fail to review it occasionally. Experiments have shown that one review, introduced a day or so after the original fixation of a habit or set of facts, is of more benefit to memory than five or six extra repetitions at the time of the original learning. In fact, if two or three reviews are made, one after the lapse of a day and another after a week or month, the facts will be retained almost indefinitely without further effort. Many persons have a repugnance for reviewing because the material reviewed lacks the freshness of the first contact with it. This can be overcome by forming a fixed habit of reviewing at appropriate intervals. The best way to review effectively is by active performance, or recitation.

Summary

This chapter has emphasized the fact that many people fail to attain the level of efficiency and achievement they would like to reach because they never perfect their skills and knowledge by systematic learning. The common deterrents, such as lack of confidence due to age, limited time, mistrust of one's ability or energy, are shown to be based on a misconception of what is required. All these factors can be overcome, provided we select carefully the essential things to be learned in the light of our particular capacities. An analysis of the process of economical learning shows that accurate observation and careful organizing are the first prerequisites. Next comes the process of fixing, and this requires putting what is learned to immediate use and letting the law of effect operate. To secure the stimulating effect of knowing the rate of progress, a learning curve should be kept, indicating day-to-day improvement in speed, accuracy, or quality of performance, and reduction of effort.

If the improvement sought is mainly a matter of unlearning or breaking previously learned habits, certain rules are worth following, namely, to substitute a correct or good habit for the incorrect or undesirable one, to give attention exclusively to the correct act, and to make the performance of the incorrect act as disagreeable as possible. The problem of retaining what we have already learned reduces to a matter of avoiding the factors which cause forgetting, such as associative interference, change of the stimulus situation, under-learning, and lack of adequate reviews.

Avoid over-burdening the memory with unessential facts and habits. Reduce everything possible to written memoranda. Concentrate on a few important things and master

them. Then enjoy the confidence that comes from being an expert, or at least a competent performer.

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Chapter XV

THE EFFECT OF AGE CHANGES ON EFFICIENCY

We begin to grow old from the time we are born. There is no period in life that can be set off and designated as the time when we start to age. Whether it is physiological age or psychological age that we are talking about, the statement still holds true. From birth until death, a continual series of changes is taking place, in which alterations in physique, in endocrine glands, and in metabolic activity are occurring. These various changes overlap. Some, like the atrophy and absorption of the thymus gland, are practically completed by the time adolescence is reached. Others, such as the development of the sex functions, are just beginning; these, in turn, recede around the late forties. Still others, like the changes in bony structure, go on to extreme old age. Are there corresponding changes in efficiency? Can we say that there is an abrupt point at which decline in physical and mental activity starts, or is this too a matter of overlapping processes, in which some powers are rising while others are declining? When we are young, can we be said to be young in all respects? When we grow old, do we grow old all over, or do some faculties persist practically to the end of life? The answer to this question has tremendous significance for the problem of personal efficiency, because the commonly accepted belief is that when a man passes a certain age he ceases to be an asset economically and becomes a liability. Let us consider, first, some of the evidence regarding changes in physical efficiency, and second, the results of mental measurements on adults.

Changes in Physical Efficiency with Age

Among the more obvious physical powers which suffer a decline that is considerably accelerated after 40 years of age are vision, hearing, and heart and circulation, as far as the arteries are concerned. In the case of women, the menopause, setting in between age 45 and 50, marks a period of the slowing down of the endocrine gland functions, and an alteration of the emotional life which, however, may be for the better, once the climacteric is passed. An analogous change in men that occurs a little later often causes a slowing up in drive and some depression and feelings of inadequacy, instead of the emotional instability which women suffer. But they too usually emerge into a period of calm serenity. It is said that people under forty are better off if they are slightly overweight, while those over forty are better off if they are slightly underweight. This is in recognition of the fact that the young are more susceptible to pulmonary diseases, and those past forty are more susceptible to circulatory ills and kidney and bladder troubles. Furthermore, mental diseases show a sharply rising curve after the 55th year.

Sheer physical strength and muscular agility are at their peak between 20 and 30 years of age. A boxer or baseball player is old at 35. The Army prefers men under 25 because they can take the grueling exertion and they have greater flexibility. But this type of explosive effort is not the kind called for in most vocational fields. Skill is more in demand and, once acquired, may show little decline throughout middle life. A compensating factor is the fact that, although young men are more agile and alert, they have less judgment and take chances. Thus, in automobile driving, the accident rate declines up to age 40 because of the greater caution, slower driving speed, etc., of the older man. After

that, poor vision and muscular unsteadiness begin to show, but still the rate does not equal that of youth under 20. If we consider individual cases rather than the general average, we occasionally find people who retain their skill in sports until 70 years of age. Usually they are persons who began early to cultivate a good physique and who have kept it up all through the middle years. Another fact which points to a retention of basic skills throughout life is the steady decline in frequency of accidents among employees in many industries between the ages of 20 and 60.

Changes in Mental Efficiency with Age

How does age affect the thinking machine? This question, even more than the one about physical decline, must be answered only with reference to one type of mental activity at a time, because each mental function behaves differently from every other. No blanket statement can be made that is not misleading. Moreover, all statements must be thought of as applying only to the average, for the deviations are wide. Chronological age is a very poor guide to mental age because some persons are still young mentally long after others have undergone senile decay.

Changes in General Intelligence.—For evidence regarding the rate of decline in general alertness or adaptability, the type of thing that is measured by our standard intelligence tests, we turn to studies like that of Miles (2). It has long been known that mental alertness reaches a peak during the ages between 15 and 20 for the majority of people, and possibly between 20 and 25 for the very superior. The curve can now be carried to old age, and we can see what happens in the intervening years. Refer to the curve in Fig. 17. According to the data of Miles and others who tested hundreds of persons of all ages, including whole communities, so as to

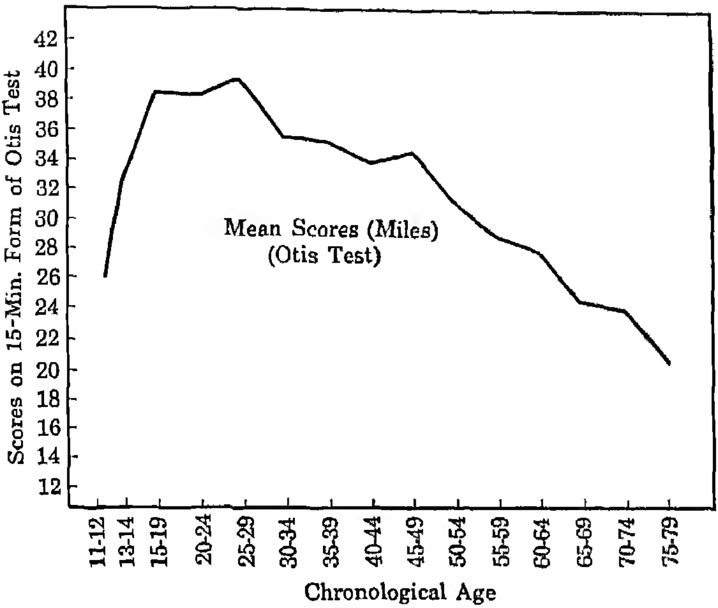

FIG. 17.—Growth and decline of intelligence from 10 to 80 years of age. (From W. B. and C. C. Miles, in *Amer. J. Psychol.*, 1932, 44, 44–78.)

secure representative samples, a very gradual decline sets in at about 25 years and continues to the 45th year, at which point the loss does not exceed more than a year or so of mental age, or between five and ten points in terms of the intelligence quotient. It should be explained that the average intelligence quotient is 100, and that the normal range of intelligence, which includes more than half the population, lies between 90 and 110. Therefore a person whose I.Q. at age 20 was 100 could be expected to have an I.Q. of between 90 and 95 by the time he reaches 45. Thus he would still be within the normal range for young adults. Beyond the age of 45, however, the decline becomes steeper. Even so, it is only in respect to the type of intellectual ability which re-

quires rapid adjustment to new situations that this marked decline shows itself.

How about the people whose intelligence level in early maturity is somewhat above the normal range? Shall we look for a greater proportional decline or about the same amount? Apparently the rate is about the same as that of persons within the normal range. This means that an individual whose I.Q. at age 20 was 120, or about that of the majority of university students, would have an I.Q. of between 110 and 115 by 45 years and at 65 or 70 would still be equal to the average young adult. Moreover, if he continues to exercise his brain with sufficiently varied intellectual tasks, even this amount of decline can be considerably lessened.

Changes in Learning Ability.—One of the abilities commonly supposed to suffer an early decline is memory, particularly the phase of it that involves learning new things,

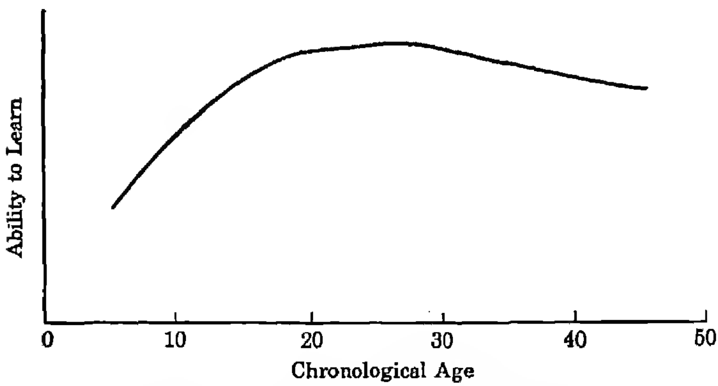

FIG. 18.—The general form of the curve of ability to learn in relation to age. (From E. L. Thorndike and others, *Adult Learning*. By permission of The Macmillan Company, Publishers.)

forming habits, acquiring facts. Yet careful investigations do not bear out this popular belief (4). In fact, if the rate of learning, of both acts involving simple motor skill and

those of a more intellectual type, is studied from age 20 to age 40, the decline is scarcely significant. In some things it reaches 25 or 30 per cent, but in others shows no decline at all and in some cases even a slight gain. For example, the older group showed as much speed in learning stenographic symbols as the younger, and about equal facility in acquiring typewriting. A wider range of ages, up to 85, was studied by Ruch (3) in a rather unique way. He compared the capacity of the various age groups to learn under two quite different conditions. In one they merely had to learn a new habit, either motor or verbal. In the other they had to learn a new habit which was contradictory to some lifelong habit, in the sense that the statement "three times six equals fourteen" is contradictory. He found that, under the first condition, the middle-aged group were only slightly inferior to the young people, and the oldest group, made up of persons between 60 and 85, only showed a 20 per cent loss. But under the second condition, where they had to break up old habits in order to learn the new, the oldest group showed a 50 per cent loss of capacity. Previously learned habits seem to undergo a crystallization process which makes any change more difficult. This is probably the basis for the increasing conservatism in politics and in other fields of thought displayed by those of advanced years, and for the reluctance of persons in late middle life to change their occupations.

Changes in General Information.—One of the aspects of mental equipment which seems not to undergo any decline with the years is the breadth of knowledge or the total fund of information. For example, vocabulary remains constant, and ability to answer factual questions in a wide variety of fields holds up well. The surprising display of long-time memory by the aged, in which they clearly recall events of their childhood, should convince us that the occasional lapses of memory we discover in ourselves as we grow older

are not to be taken too seriously. We do not trust our memories enough. We have an emotional dread of forgetting which sets up an inhibition against recall.

Changes in Judgment.—Judgment is one of the most difficult traits to appraise. But to the extent that sound judgment is based on wide knowledge and on the ability to bring experience to bear in making decisions, to that extent judgment should ripen with the years. Ability to arrive at correct decisions in a field with which we are thoroughly familiar consists in seeing the analogy between the present situation and past situations which have been successfully dealt with in a given way. Good judgment consists in applying such well-tried methods to the present situation. The younger person has not accumulated a fund of well-worked-out principles to guide his judgments. On the other hand, in a field which is very new or in which radical changes occur constantly, a fund of accumulated wisdom may be a hindrance rather than a help. The unencumbered mind may be more flexible. The most successful generals in World War II have been those who could quickly discard traditional practices and strike out boldly in untried directions. Those who could only hide behind their antiquated mental Maginot Lines went to pieces in the crisis.

Age Changes in Motivation and Attitudes

While the physical and mental changes discussed above are responsible for many of the differences in individual performance in later life, they do not tell the whole story. In fact, to a certain extent, these changes are not so much indicative of differences in fundamental capacity as of shifts in the intensity and direction of drives, and of attitudes. These stem partly from biological factors, but social pressures are equally responsible.

Alterations of Biological Drives.—In youth and early manhood the strongest pulls are in the direction of securing a mate, providing for and rearing a family, and fighting for a place in the business or professional world. This is followed by a period in which social prominence and a career monopolize interest. By the early fifties, the subjective experience of gradually weakening physical strength and subsidence of glandular stimulation leads to a complete shift of interest. Security becomes the major drive. There is a withdrawal from the intense competitive attitudes, the love of the struggle which characterizes early manhood. There is a shift in both strength and kind of drives. But there is also greater stability, a greater interest in life in the abstract as opposed to the immediate, vital stresses of personal ambition.

Changes in Attitudes.—Coupled with the shift from the biological drive toward carving a place for oneself and one's family, which necessarily involves disrupting the *status quo* at least in a small way, to the biological drive toward security, which means maintaining the *status quo* against the inroads of the oncoming generation, there is a change in fundamental attitudes, from radicalism or progressivism to conservatism. This change permeates everything the older person does; it is reflected in his business policies, political attitudes, dress, financial dealings, everything.

Changes in Fatigability

One important question, from the point of view of work efficiency, is this: Do older people show more rapid mental fatigue? Is there an important alteration in the mental energy level or in the constancy of mental output? As far as the maximum level of effort is concerned, it is decreased. There is not the capacity to rise to temporary peaks of in-

tensified activity. But in compensation for this there is a greater steadiness, a more continuous output at a lower level. The nervous energy manifests fewer spurts and a steadier flow. There is another important difference. The superabundance of energy of the young person is often not well concentrated in productive channels; it is dissipated in extravocational directions. Social activities, evening distractions, the need for siphoning off nervous excitement in many directions—all these detract from concentrated efficiency. The older person's energy, on the contrary, what there is of it, is available for the job.

Age and the Productivity Curve

One way of finding out the effects of age on mental productivity is to study the output of men in different intellec-

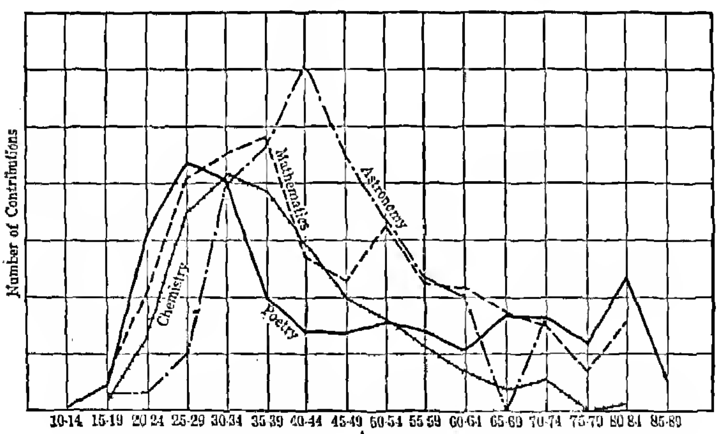

Fig. 19.—Ages at which contributions were made by outstanding workers in various fields. (Adapted from H. C. Lehman. [The creative years in science and literature, *Sci. Mo.*, 1936, 43, 151–162], by S. L. Pressey and others, *Life: A Psychological Survey*, Harper, 1939.)

tual fields whose works have remained as a permanent record so that they can be analyzed from three points of view: first, the age at which he produced his best work; second, the span of years over which productivity stretched; and third, the relative volume at different ages. Of course, famous men may differ from the average in important ways, and we cannot apply the facts too rigidly to our own lives. But without doubt the same factors of energy level, biological drives, and social pressures which operated in the lives of these scientists and intellectual men to produce the curves of productivity shown in Fig. 19 are also operative in our own lives to produce similar curves of occupational efficiency. These curves were obtained by Lehmann (1) by checking the dates of appearance of books or articles against the ages of these famous men from 20 to 80 years. Consider the curve for scientific productivity. The output rises sharply from age 20 up to about 35. Then there is a gradual drop from the peak and the curve levels off in the sixties; this is followed by a slight spurt in the seventies. The bulk of the output occurs between 20 and 50, but more than one-fourth of the total is contributed after this age. Poetry shows an earlier peak and a more rapid decline. On the other hand, philosophy does not reach maximum volume until after 40. This is what we might expect on the basis of a shift in biological values and interests.

What of the quality curve as contrasted with the quantity curve? There seems to be no great difference in the location of the peak. The main difference is in the greater concentration. By the age of 70, practically none of these thinkers was producing his best work. Another point to consider is the fact that a man may do the thinking which goes into his later work while he is still relatively young, but delay the presentation of it, either to check and refine it further or because of the pressure of other matters. There is probably

a lag of a few years between the productive thinking and presentation to the public.

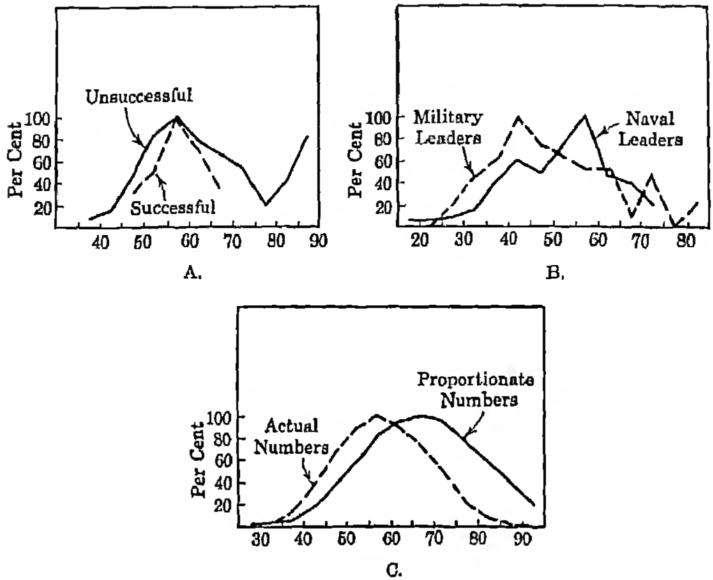

FIG. 20.—Leadership in relation to age. *A* shows the ages at which men have been elected President of the United States or have been candidates. *B* shows the ages at which military and naval leaders fought outstanding campaigns. *C* shows the ages during which men have held leadership in business. (Adapted from H. C. Lehman, Optimum ages for eminent leadership, *Sci. Mo.*, 1942, **54**, 151–162.)

It is interesting to contrast mental productivity with physical or sensory-motor productivity. We mentioned before that athletes reach their peak performance at 25 to 30 years of age and by 35 are no longer able to compete. In sensory-motor performance the decline is somewhat retarded. In intellectual performance a man is just rising to his peak output at the time of life when the athlete has already stepped down. If we were to extend our study to include judges, Senators, Presidents, and the like, we would find that

the entire life span is needed to sample the various ages of peak productivity for the different kinds of intellectual performance. Fig. 20 shows that leadership reaches its peak efficiency after 50 years of age.

How to Counteract the Effects of Age

We have had an opportunity to survey the age changes in many different activities. Aside from the encouragement to be derived from knowing that the picture is far brighter than popular impression would have us believe, there is little advantage in merely knowing the facts. What we want to know is: Can anything be done to counteract the age trend and prolong the period of productivity? The answer can be given definitely in the affirmative. This is truer in regard to the mental aging process than it is in regard to the physical. There follow some concrete suggestions to this end.

Exercise for the Mental Machinery.—It is a well-known fact, and one with which we are all familiar, that when a muscle is unused for a long period of time it atrophies. This change is not confined to old age but can take place at any time of life. If the muscle is exercised in time, before the atrophy has set in, it can be saved for later usefulness; otherwise it is permanently lost. We have said enough in this book about the physical basis of thought and mental work to make it clear that the same type of change can take place in the brain and nervous system as occurs in unused muscles. One reason is because brain tissue is filled with minute blood vessels which carry nourishment to the nerve cells with which we think. When no demand is put on these tissues for work, the circulation gradually deteriorates and, if called on later to function, they no longer respond. The alert mind depends on a healthy brain, and this in turn requires constant exercise. As in the case of the muscles, the deterioration

process is not confined to old age; it can set in any time. The only insurance against it is to keep the brain exercised by such a varied program of mental activities that no part is allowed to atrophy from disuse. To a certain extent, the brain functions as a whole, but the metabolic activity is always more intense in some regions than in others. The ideal situation is to distribute the load so that all parts share in the quickening effect. To achieve this end, every adult individual will find some of the following steps of ultimate profit to himself in the prolonged usefulness of his life and his greater satisfaction with it.

Adult Education.—The antiquated notion that education should end with graduation from a secondary school or college is gradually being given up. There is no possible defense for such an idea. On physiological and psychological grounds it is certainly absurd. Why put into cold storage all that we have learned up to this point in our lives? Experimental evidence shows that a man's intelligence stops developing at just about the point at which he ceases his schooling. There is every reason to suppose that if he resumes his education later, when he is financially able to do so, he can actually raise his intelligence somewhat. What sort of mental pabulum is best for this purpose? The answer is, anything which requires thinking in terms of symbols, whether verbal or mathematical. The ability to manipulate abstract symbols is the essence of higher intelligence.

Reading and Travel.—Next in importance to adult education classes and programs is a wise choice of reading. Because in these times of economic pressure education is conducted to prepare for a vocation, few men are really educated. Students are rushed through the preliminary subjects and then hustled into a field of specialization with no opportunity to browse around in other fields of knowledge. Adult education can help to remedy this, but so can a wisely selected

program of reading. Travel may or may not be intellectually stimulating, as the following poem (5) suggests:

"Sailor," said I, to the sunbrowned lad
With the mariner's rolling gait,
"What glorious cruises you must have had
From Oporto to Bering Strait!
You have seen the flying fish skim the foam
Where the Gulf Stream rippled blue,
And the cachelots spout in the darkling gloam
(As I've read that they often do).
Tell me of every thrilling cruise,
Talk of the life you've led."
"The movies was good down to Newport News—
None better," the sailor said.

"But, sailor," I cried, "you have seen whole fleets
Of the Portuguese men-o'-war,
You have heard the whine of the brine-wet sheets
As you beat off a lea-ward shore;
You have cleft a track through the green sea moss
While it clung to your rusty prow;
You have glimpsed the gleam of the Southern Cross
As it rose on the starboard bow.
From Pe Chi Li to Matanzas Bay
You have breasted the rolling tide—"
"There's plenty o' hooch down Havana way—
Swell licker," the tar replied.

Accepting Responsibility.—There is nothing quite so stimulating to the mind as accepting new responsibilities. Men who have responsible positions thrust upon them usually grow in mental stature as a result. The opportunities for assuming wider responsibilities are not confined to our vocation. We can all broaden our community contacts and accept civic responsibilities, thereby both benefiting the community in which we live and pulling ourselves out of an intellectual

rut. One of the few good results of a world war is the necessity and opportunity it gives to vast numbers of people to assume new responsibilities and make new stimulating contacts in carrying out civic duties. A war seems to galvanize effort in a way that peace-time activities never do.

Summary

In this chapter we have been concerned with those changes of a quantitative and qualitative nature which occur in the physical and mental equipment of individuals as a result of growing old. The picture is one of overlapping trends, in which some capacities are declining while others are rising to a peak. There seems to be no abrupt point of transition from the period of usefulness to that of incapacity. Mental alertness declines more rapidly than learning ability, and general information apparently suffers no loss. Judgment, on the contrary, increases for those types of situation which do not undergo too rapid changes. Motives and attitudes shift in the direction of conservatism, and energy levels off, becoming more stable even as it loses altitude. The productivity curve suffers more in quality than in quantity, but even this varies with the exact nature of the task. Some forms of intellectual usefulness do not ripen until well past middle life.

The lesson in this whole chapter for the average person who is approaching middle life is to take the time and thought necessary to reappraise his capacities in the light of the changes we have indicated. There need be no narrowing of the field of usefulness; all that is necessary is a shift in the direction of activity, so as to utilize more the powers that mature late, even as he relinquishes those which decline early.

The entire aging process, physical and mental, can be delayed by keeping the body and brain healthy through use. Ways of doing this through adult education, reading, and the deliberate acceptance of broader vocational and community responsibilities were suggested.

The next chapter will be concerned, among other things, with self-appraisal. The most vital time for a thorough self-appraisal is when a person is embarking on his vocational life and wants to make the most of his gifts and capacities. But a second important time is the period we have just been discussing. All the methods suggested in the next chapter can be applied here as well. It is not at all unusual for a person who has been more or less of a misfit during his early years to discover his most congenial occupation relatively late in life. General Grant never amounted to much until he was well past forty years of age. At the time the Civil War began, he had a job delivering cordwood. By the time the war was over, he was not only commander of the northern forces but was being considered for the Presidency of the United States. Obviously he possessed latent talents which had never been called forth by the jobs he had tried previously. But it is also probable that he could not have utilized those talents to such good advantage until he reached the age of ripened judgment. That is why a reappraisal is often so valuable.

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Chapter XVI

SELF-APPRAISAL AND SELF-IMPROVEMENT

When a good workman prepares to do a delicate piece of work, he is very careful in choosing his tools. He does not attempt to drive screws with a chisel or to cut iron with a wood saw. We can say, by analogy, that a man's body and brain are his most important tools. To apply them to a job for which they are not suited is as economically wasteful and as unsatisfactory to the individual himself as it is to try to work with the wrong equipment. This is self-evident. Yet we find, if we look about, that the vocational world is full of square pegs in round holes and round pegs in square holes. The reason is because people have not yet learned how to appraise their own capacities and interests in an adequate way, in order to discover the type of career or job to which their special aptitudes, personality traits, and emotional preferences are best fitted. Employers and personnel officers are constantly widening their use of the testing devices which have been prepared by psychologists for this purpose. Anyone applying for a job these days is almost sure to encounter such testing programs. Usually, however, the personnel man is interested in selecting applicants for a particular job or in reshuffling them after they have been employed. A few agencies, like the U. S. Employment Service, attempt a broader sort of appraisal. The alert individual should not entirely overlook the matter of self-appraisal until he is at the stage of his career where he is actually seeking a job. Everyone should become as thoroughly acquainted with himself and his potentialities as he possibly can before he ever chooses a vocation.

The Dimensions of Human Nature

There are four main directions of variation among human beings which have a vital bearing on vocational life. We might call them the dimensions of human nature. These ways in which individuals differ are classifiable under four main categories:

Differences in general aptitude
Differences in special aptitudes
Differences in personality traits
Differences in interests or preferences

In the following pages we shall discuss briefly the extent to which people vary in these four directions; the kinds of tests that are available by means of which anyone, with the assistance of a psychologically trained adviser, can determine his own pattern of traits; and the answers that these findings should give him about the type of vocational career he should choose. A full exposition of these topics is beyond the scope of this book, but several good treatises are available which can be consulted by those who wish more detailed information.

Differences in General Aptitude

The term aptitude is used by psychologists in a special sense, to mean capacity before it has been developed by special training or practice. To a certain degree it designates native ability, but it is also dependent on a normal background of general schooling and culture. Everyone possesses a certain degree of mental alertness, ability to learn and understand, but the degree varies greatly with the individual. This has been called "intelligence," but the term leads to so many false notions that it is safer to call it "general aptitude."

Success in school work and in all complex mental activities shows a close dependence on the degree of possession of this trait. Language ability and ability to deal with abstract symbols like those of mathematics and the sciences seem to have an important relation to it. For this reason it has sometimes been called "scholastic aptitude." This, however, gives a false impression that it has no practical value or significance in life beyond school. But, above a certain minimum occupational level calling for purely routine thinking, this general aptitude factor does have significance; and as the level rises to occupations requiring more complex mental operations, it becomes increasingly significant.

There is good reason for calling this factor "general" aptitude, because it is the broadest of all the aptitudes and has some bearing on nearly everything we do. This is a matter of degree, for some abilities are less dependent on it than others. For example, mechanical ability seems to be relatively independent, so that persons with a high degree of mechanical talent, such as is required in constructing, repairing, and manipulating mechanical devices, may or may not possess much general aptitude. On the other hand, people with good general aptitude may have very little mechanical ingenuity. Creative work of a high order in this field requires both. Another example of a special form of ability or talent that is only slightly dependent on general aptitude is artistic talent. Persons may possess a native talent for graphic or pictorial art or for music, quite independently of the degree of their abstract intelligence. Again it must be admitted that a high level of creative work in these fields requires both talent and capacity to think abstractly.

Degrees of general aptitude may be expressed in a number of ways. These conventions have resulted from quite different practical demands. One is the need to measure the progress of children as their intelligence increases with age.

Standard tests are available for each age between 2 and 15, at which point the growth of this trait ceases for the average person. It is possible to say that any child, no matter what his age, who can pass the complete test for seven-year-olds has a mental age of at least 7. If an adult takes an intelligence test, his ability can also be expressed in terms of mental age units. The mental age of the average person is about 15. This means that he can answer correctly those test questions which are designed for fifteen-year-olds, but cannot answer harder ones because the growth of general aptitude ceases at about this age for the person of average ability. More difficult questions have been devised to test people with superior ability.

A more common measure is the intelligence quotient. This also was designed to be used with children. It shows whether a child's mental advancement is average for his age, or retarded or advanced. It is simply a ratio between chronological age and mental age. For example, if a child of six has a mental age of six, he is just average. An average child's mental age and chronological age are always the same. The resulting ratio, when the mental age, say 7, is divided by the chronological age, which is also 7, is 1 or unity. This is arbitrarily called 100. Therefore the child is said to have an I.Q. of 100. Suppose a child of 7 has a mental age of 6. He is somewhat retarded in mental development; his mental age divided by his chronological age gives a ratio of 0.86, which is arbitrarily read 86 just as 1 was read 100 in the case of the average child. This child is said to have an I.Q. of 86. Now suppose a child of 7 has a mental age of 8. He is somewhat advanced for his age, as the ratio of 1.14 shows. This child, with an I.Q. of 114, is said to be superior.

This form of designating general aptitude has been carried over to adults because the degrees of advancement or retardation which appear in a child tend to persist when that child becomes an adult. The average child becomes an

average adult. The superior child becomes a *superior* adult. The retarded child is still backward when he reaches maturity. But the application of the concept of I.Q. to adults presents many difficulties. The only reason it is so widely used is that it has become popularized and many people feel that they are more familiar with it than with more suitable scores which psychologists are now substituting for it, such as "percentile scores" or "standard scores."

Most general aptitude tests for adults yield point scores based on the number of right answers; but to satisfy people who prefer to use intelligence quotients, the makers of the tests issue scales for directly translating point scores into I.Q.'s. An example of this is the Otis Intelligence Test for Adults.

What do I.Q.'s mean in terms of vocations and professions? There are various ways in which they can be given meaning, but all of them are subject to erroneous interpretation unless common sense is used in applying them to the individual case. Perhaps the simplest way of giving I.Q.'s a broad general meaning is to say that

The average I.Q. of adults whose schooling terminated at the end of primary school is between 90 and 100.

The average I.Q. of adults whose schooling terminated at the end of high school is nearer 110.

The average I.Q. of adults who finished college is about 120.

These are only averages, and there are all sorts of exceptions; but with a framework like this to work with, we can answer some questions about vocations and professions. The so-called learned professions, such as medicine, law, advanced teaching, and engineering, require the ability to take training at a university level of difficulty. They require I.Q.'s of 120 or better. Business and clerical vocations cannot be so easily pigeonholed. For example, a girl who does only routine

typing might qualify with an I.Q. of 100, but one who composes letters for her employer when he is absent will require a higher level of ability; some private secretarial jobs call for a degree of mental aptitude equal to that of the professions. Although skilled and semi-skilled trades often depend more on factors like mechanical ability, the average I.Q. requirement is around 100. Unskilled and agricultural work are the least exacting. The average I.Q. of unskilled laborers is 90 to 95. Some of these jobs can be handled by persons whose I.Q. is as low as 60, provided they are carefully supervised.

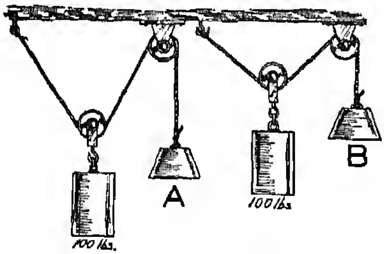
Those who are most familiar with the measurement of general aptitude are coming to feel that it is not a unitary factor, but can be further subdivided with advantage into a group of primary abilities, of which the ability to use and understand verbal or language symbols, called L, and the ability to manipulate numerical values, called Q, are the most important. Thus a person may have more of one of these abilities than he has of the other; his high I.Q. may run more in the direction of L than of Q, or vice versa. This should be taken into account in sizing oneself up, because an individual with more Q than L would be more successful in the exact sciences and engineering; whereas one with more L than Q would fit best into law, social science, journalism, teaching, or the ministry. There is a tendency, however, for these dimensions to vary together; at least the person who is high in L is more likely than not to excel also in Q. A test which distinguishes between these aspects of general intelligence is the American Council on Education Test, edited by Thurstone (9).

Differences in Special Aptitudes

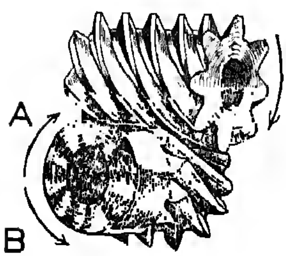
Special aptitudes include all those abilities which lie outside the group of general aptitudes just discussed. Examples

are mechanical aptitude, artistic talent, and musical talent. A person who plans to enter the field of architecture or commercial art in any of its forms should have a reasonably high degree of artistic feeling; without it he would not advance far even with a superior I.Q. Here also, we can further subdivide the artistic aptitude into two or three components, such as aesthetic feeling and graphic skill. Tests have been devised for discovering these talents in advance of any special training. One of these tests is the Meier Art Judgment Test (5).

Mechanical aptitude enters into so many of the skilled and semi-skilled occupations that it is necessary for a person who plans to enter any of them to know his potentialities and limitations. A record of having built toy models of boats, airplanes, and engines, or of having monkeyed with wireless



39
Which weight must be heavier to support the 100 pounds in the position shown?



51
If the upper gear turns in the direction shown, in which direction will the lower gear turn?

FIG. 21.—Two items from the Bennett Test of Mechanical Comprehension. (After one form of the Test of Mechanical Comprehension, by G. K. Bennett, by courtesy of the Psychological Corporation, New York.)

sets, during childhood and youth, is a pretty good indicator of the possession of mechanical talent; occasionally, however, it indicates only that the individual had a strong liking for these things, but no special talent. Therefore, an adequate test is needed. Several such tests are available. Not all of them test the same ability, and some of them test an ability at a higher level than others do. For example, the Stenquist Assembly Test (7) calls for the actual reassembling of common mechanical devices, like locks, which have been taken apart. Others are of the paper and pencil variety; these require that one of a number of alternative answers be checked. By presenting pictures of situations, the Bennett Test of Mechanical Comprehension (1) calls for an understanding of mechanical principles on a non-verbal level. One of the questions is reproduced in Fig. 21. For a test that gets at ability to visualize in three dimensions or two, and to assemble blocks of varied shapes mentally, the Minnesota Paper Form Board Test, widely used, is excellent. On a much simpler level of mechanical skill are the tests which determine manual dexterity on the basis of manipulating objects with the fingers, such as the O'Connor Manual Dexterity Test (6).

Achievement Tests

Up to this point we have been concerned with the measurement of capacities before they have been developed by special training. Often, however, a person has had a certain amount of formal training or previous experience in a given vocational field which he can bring to bear in qualifying for a job in that field. Mere amount of training or experience is no index because some people benefit much more than others from training. In such cases a test which indicates an individual's mastery of the field is needed. Such tests are called

achievement tests. Dozens of them are available, and they have been standardized for many different fields. They are no substitute for aptitude tests, because in the long run a person with high aptitude and little or no experience or training in a given field can be depended upon to outstrip others with plenty of experience. For a time, though, he will be handicapped. Sometimes we wish to determine how much a given individual is likely to profit from further training. In this case it is necessary to know three things, the I.Q., the special aptitude score, and the achievement score.

Differences in Personality Traits

It is not at all uncommon for an individual who is planning to enter a certain vocation or take a certain job, to possess the requisite abilities and aptitudes, and even the special training, and yet be unfit for the type of work because of his personality pattern. For example, he may be considering a career which requires him to sit in an office and offers no opportunity for energetic physical activity or change of scene. Yet he may have an ingrained distaste for sedentary life; he may prefer to be moving about actively. In psychological language, he is hyperkinetic. Such a person might be miserable in the very job for which he is well fitted by capacity, simply because of temperamental factors. Conversely, an individual who shuns physical effort and loves his home would make a great mistake in entering a career as traveling salesman or construction engineer.

Consider another example. Some people enjoy directing the activities of others and making their decisions for them. Other people much prefer to have someone else direct them or lay out their work for them; they will go ahead and carry it out. Responsibility floors some people, whereas others thrive on it. Hence, the fact that a person is very good in a

certain field, in the sense that he has a wide knowledge of it and great proficiency in the operations involved, is no guarantee that he would be successful or contented if he were given the job of directing or teaching others in that field. Emotional instability, which may be no particular handicap in some fields, is a handicap to individuals who must deal with other people in emotion-provoking situations. Again, there are people who enjoy working with others and who become despondent when they work alone, because they miss personal contacts. But there are others who are happiest when left completely to themselves. Both types are needed—we have to have forest rangers as well as secretaries of social clubs. How unfortunate for an introvert to find himself secretary of a social club, or for a back-slapping extravert to be inveigled into a job as a forest ranger because he has a thorough knowledge of trees!

A person who understands himself well will take into consideration all the aspects of his personality in choosing a vocation or job. Few people, however, have enough insight to understand all their temperamental peculiarities without the help of diagnostic tests. A large number of such tests have been devised, covering such traits as introversion-extroversion, dominance-submissiveness, emotional instability, self-sufficiency, sociability, self-confidence, honesty, masculinity-femininity, and the like. The Bernreuter Personality Inventory (2) covers six traits. It is a questionnaire, in which the person taking the test is asked how he habitually behaves in a number of different situations. His responses are scored in proportion to their importance, and a total score in each of the traits is assigned. If this test is taken by someone who is more interested in making a desirable score than in discovering his true personality, the results are not significant; but if he is appraising himself and is trying to arrive at a true picture of himself, the results may be highly significant.

The point is that we may know beforehand that we are somewhat introverted or somewhat timid socially, but we are not sure whether we are more so than the average person, or what it means in terms of our probable success in a given field. The results of a test will tell us whether we possess the trait to a low or high degree as compared with other persons.

Knowledge concerning the following aspects of your personality is important in choosing a vocation:

Are your main interests external to you, in the things and people about you, or are they concerned more with abstractions and your own thoughts?

Do you worry about many things and do you have many unsolved personal problems, or are you well adjusted emotionally?

Do you enjoy taking responsibility or does it bother you?

Do you like to be with people, both while working and socially, or do you prefer your own company?

Do you like the admiration of people and do you enjoy performing for an audience, or do you shrink from "showing off"?

Do you have confidence in yourself, or do you tend to depreciate your worth in comparison with others?

Are you happiest when telling others what to do, or when following the directions given you by a supervisor in whom you have confidence?

Can you carry through to completion a long and tedious task or program which you have undertaken, or do you tend to abandon enterprises when they reach the irksome stage?

Do you like to move about and have frequent changes, or to stay in one place?

Do you prefer to work slowly and carefully, attending to fine details, or to cover a lot of ground even though some parts are sketchily done?

When a person has found out by tests where he stands

in each of these traits with reference to other people, he can prepare a chart like the one in Fig. 22. This is constructed by listing the traits in a vertical column at the left, then drawing a horizontal line after each trait and dividing it into ten equal scale divisions. These divisions represent degrees of the trait, from the lowest degree, or 1, to the highest, or 10. The next step is for him to place a mark at the point on the line after each trait which represents his own degree of possession of the trait as shown by his test score. The marks are then connected by a continuous line. The resulting figure is called a "psychograph."

The two psychographs represented side by side are for two individuals who would be well fitted temperamentally for two quite different careers. One would make a good traveling salesman, the other a laboratory technician. We leave it to the reader to decide which is which.

Differences in Interests or Preferences

Let us suppose that a person has discovered what sort of career or job he is fitted for by ability and temperament.

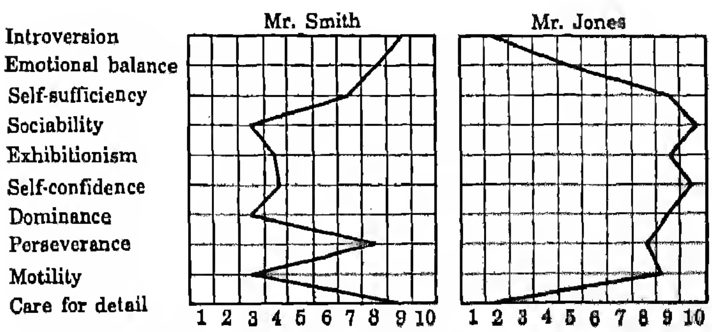


Fig. 22.—Two psychographs indicating fitness for widely different vocations.

There is still one more step—he must consult his interests. If he is not at all excited about a given career or job, he should think twice before entering it. Liking an occupation is half the battle in succeeding in it. Frequently these likes and dislikes agree with the individual's talents and temperament, but not always. If a person does a certain thing well, he is more likely to enjoy doing it. But there are many other determiners of preferences. For example, a certain young man wants to be a doctor because his family physician was very kind to him as a boy and he wants to be just like him; he has made a hero of him and would like to follow his career. A young woman who has read romantic stories about the heroic lives of nurses thinks that this would be the best way to serve humanity. A lad trades a slingshot for a mouth organ, and is praised by his father for his business acumen. Thereupon he decides to become a financier, and still clings to his boyish dream when he reaches manhood. Out of such trivialities are vocational preferences born. But once fixed, they are difficult to change.

The ideal way to discover what our own preferences are, and whether they are superficial or really fundamental, would be to be given the opportunity of seeing all the inside workings of the occupation we have selected. This would either convince us that we were on the wrong track or confirm us in our preference. Many a young man who plans to be a doctor has been turned aside when he found out the amount of chemistry and anatomy that is required. Many a prospective nurse has discovered too late that a bloody operating room or a long spell of tramping wards did not fit into her romantic picture of a nurse's life.

Because it is out of the question for everyone to have a preview of this sort, special questionnaires, called Interest Analysis Tests, have been devised to achieve this purpose as well as a paper-and-pencil test can do so. These question-

naires list as many of the duties and activities of each profession or vocational field as possible; the person taking the test indicates whether he likes or dislikes each of these activities. The tests cover all the major vocational fields, so that any marked preferences and also any marked aversions are indicated very well.

An early test in this field, and one that is still the most widely used, is the Strong Interest Analysis Blank (8). It lists 32 vocations, for which preference scores can be obtained by sending the blank, properly filled out, to Stanford University. A more recent test of similar design is the Cleeton Vocational Interest Inventory (3); this is easier to score, though not quite as reliable. Still another is the Kuder Preference Test (4). All of them are valuable in selecting the one or more vocations embodying the activities and duties which the individual taking the test will find most congenial. Conversely, they quickly indicate the vocations that involve activities which are uncongenial to him. The items in the test blank for women differ from those in the men's blank, but represent vocations adapted to a wide range of abilities and interests. In using the results, the individual may decide not to follow his first preference because he lacks preparation for it or the time to prepare, or because he does not possess the aptitudes or the temperamental traits required. He may decide on the second or third preference.

Levels of Aspiration

One advantage of a thoroughly objective appraisal of one's capacities is that it enables him to readjust his "level of aspiration" and to put it on a sound, rational basis. The term "level of aspiration" is used to indicate a person's own estimate of the goal or level he would like to reach, and thinks he can attain by putting forth the amount of effort that he

is willing to expend for this purpose. It depends on his estimate of his capacities and the amount of ambition he has. Thus an individual's ambition may exceed his ability and cause him to adopt a level of aspiration so far beyond it as to be unattainable in reality. On the other hand, his ambition may not measure up to his ability, either because he does not fully realize his capabilities or because he does not care to make the effort; he prefers to coast along, just getting by. For example, some of the enlisted men in the Army have turned down opportunities to become officers because they were unwilling to take on responsibility.

There is no advantage in either overrating or underrating our capacity. To overrate it is to indulge in wishful thinking rather than facing reality; sooner or later, this results in disaster and in a consequent disillusionment that has a stultifying effect on the whole personality. On the other hand, to underrate our abilities is to put an unnecessary damper on our efforts. The wise way is to obtain as complete and accurate a picture of our potentialities as possible, and then to adjust our level of aspiration to this picture.

Supply and Demand

There is another side to the problem of selecting a vocation; there must be a good chance of securing work in that field after one has prepared for it. This depends on supply and demand. So few people take this into consideration that there is great unevenness in this respect among different vocations. Some are badly overcrowded, while others are undermanned. This affects the ease with which a newcomer in the field can secure work, and the financial return, as well as the strenuousness of the competition after he gets in. In general, the professions—law, medicine, the ministry, teaching—are greatly overcrowded, so that the level of ability

required to compete is steadily rising. On the other hand, some fields that are less crowded and might offer opportunities have artificial barriers like trade unions, or depend on family connections and the like, as in the case of a diplomatic career.

Another consideration is the rapid change going on in the supply and demand relation. Predictions are unsafe from one decade to another, because of altered conditions. In the teaching field, for example, the war needs have increased the demand for teachers of mathematics, physical science, and mechanics so rapidly in so short a time as to disrupt the entire market. As soon as the war ends, there will be a readjustment, and these fields will be greatly overcrowded. The post-war expansion will open up new fields; this will require another rapid shift of jobs and a necessary reappraisal of manpower. The individual who has more than one string to his bow will be in the most favorable position to meet these changing conditions. It pays to plan ahead and to consult the sources that give figures on supply and demand in the major vocational fields.

Self-improvement

Thus far we have stressed the necessity of securing an accurate idea of our abilities, traits, and preparation, before allowing our interests to steer us into a particular vocation. But it would be wrong to conclude that the results of the tests are to be taken as final arbiters in the matter. Suppose that we are interested in salesmanship as a career, but the tests show that we are too introverted or lacking in self-confidence. Are these traits permanent and unchangeable, or can we alter them at will? And what of our capacities? Can a person change his I.Q.? Can he acquire such specialized capacities as mechanical aptitude or artistic talent? The

answers to these questions vary so much that they must be treated separately.

Can aptitudes be changed? Probably not to any extent after the individual has reached maturity. During the developmental years, however, they can be increased and perfected by exercise; conversely, neglect or failure to exercise them can depress them considerably. Within limits, general aptitude, or general intelligence, is determined by heredity and organic condition. But a person deprived of adequate cultural opportunities may fail to develop the native factor to the average degree, and a person with very superior cultural opportunities may exceed his normal expectations of attainment.

But if the question is, "Can a person increase his ability to perform in a given direction?" the answer is, "Yes. Within the limits set by his capacity, he can increase his ability by extra training and extra effort." An individual with mediocre ability but great ambition and application can surpass someone with superior ability who lacks these traits. However, as was brought out in Chapter XIV, there is an upper limit to every learning curve, beyond which further expenditure of energy is uneconomical. Sometimes what appears to be a lack of capacity is really only a lack of opportunity for sufficient training. For example, women as a rule are less able than men to do mechanical things like setting up machinery and apparatus or repairing mechanical devices. This may be due to a difference in what is expected of women and what they are interested in, rather than to a native difference in capacity. Similarly, men have difficulty repairing their clothes or preparing meals. That this is not due to lack of aptitude is shown by the fact that the best chefs and often the best tailors are men. The war is necessitating the employment of large numbers of women in mechanical work;

they seem able to rise to the occasion, after a sufficient period of intensive training.

Can personality traits be changed? Most psychological studies show that these traits are dependent less on native factors and more on early background and experiences than are aptitudes. The assumption would be, therefore, that they are more easily modifiable. But what is learned in the first years of life is almost as difficult to change as that which is determined by heredity. In spite of this fact, people do change as a result of later experiences. Shyness and lack of self-confidence in an adult may result not from childhood events but from rebuffs, real or fancied, received during the adolescent age when all social situations are reacted to with intensified emotion. Perhaps a severe case of acne, or the inability to dress well, or belonging to a minority group—racial, cultural, or religious—may establish the pattern. Usually it is far less important than the person thinks; other people who have much greater peculiarities have adjusted to them. The point is that the personality trait often outlives its cause. What is needed is for the individual to search his own mind and determine the source of his inferiority feeling. Often he will discover that it is no longer of any significance in his life. The realization of this, that the feeling is merely a hangover from an experience which has ceased to have any importance, will often help to remove the trait. But this is not enough. The individual must seek opportunities to prove to himself and others, by actual behavior, that the trait has been corrected. The person who is unsocial can counteract his tendency to withdraw by seeking positions of prominence, and activities in social groups. The individual who wants to develop qualities of leadership can seek opportunities to express his views in small groups, take the lead in suggesting ideas for entertainment at parties, and the

like. At first this does not come spontaneously; it must be planned and arranged for in advance. Later it becomes a habit and is easy.

To a certain extent vocations change people's personalities after they enter them. The introverted person who enters the teaching or the selling field may develop extroverted interests and ways of reacting. The individual who lacks perseverance and attention for details may acquire these traits by becoming a secretary. But it is not always safe to count on such transformations. On the average, an extroverted person is the best prospect for a successful salesman; an introverted one is most contented in a science research laboratory.

Finally, it should be emphasized that personality traits are *habits,* and require time and practice for their development. They are subject to all the rules for learning which were discussed in Chapter XIV. In addition, many personal attitudes, such as inferiority feelings and lack of self-sufficiency, result largely from suggestions which we give ourselves unconsciously. They are autosuggestions. The discussion of suggestion in Chapter XII provides a basis for a better understanding of this tendency and how to cope with it.

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Chapter XVII

ORGANIZATION AND PLANNING

THE best definition of efficiency we know is the following: "Accomplishing the most with the least effort or resources." The essence of efficiency, therefore, is organization and planning—organization of our work, and organization of our life outside of work hours. Consider some false conceptions of an efficient person.

Case A. A person who always drives himself at top speed, a human dynamo, who is so concentrated on his work that he goes about with jaw set and eyes front, has no time for friends, no time for recreation, no time for reading or getting a broader perspective on life, no time for his family.

Case B. A person who has learned how to save himself on the job by getting others to do most of his work, and by determining the minimum that is necessary to just meet the requirements of the job; who thereby releases his main energies for a strenuous life of social activity or sports; in short, the person who saves time on his job only to throw it away outside of work hours.

Both of these people are inefficient because they save at the spigot, only to waste at the bung. Organization and planning should extend to the entire life, not just part of it. The above definition of efficiency contains two terms which need to be analyzed. One is "accomplishing the most." Efficiency must always be measured in terms of a goal or goals. We can be efficient on the job and inefficient in life; we can be efficient as measured by the immediate present and inefficient for the long pull. We can be efficient in making money and inefficient in achieving happiness. The question is, what are

we trying to accomplish? Knowing this, we can decide whether or not we are really accomplishing the most. The second term is "with the least effort or resources." What resources does the individual have at his disposal? Time, ability, health and money. All four of these resources must be taken into consideration when effort is measured.

Economy of Time

Economy of time involves first of all budgeting the hours and minutes of the day so that the entire day presents a balanced distribution of emphasis. For the person whose working hours on the job are measured by the clock and are constant from day to day, the problem of budgeting time becomes one of properly apportioning the non-working hours between those he devotes to routine like sleep, meals, and chores, and those he gives to the maintenance of physical health through exercise and bodily care, the maintenance of mental health through hobbies, recreations, cultivating friends, and reading, and some form of self-improvement. For a student or a person who has to arrange his working hours every day to accommodate to a changing schedule, budgeting involves fitting in study hours or appointments so that every available minute is utilized; otherwise, hours are irretrievably wasted in the course of a week. It may seem artificial and mechanical to construct a daily time schedule in which every minute is accounted for; the advantage is that this reduces many things to a routine which can be followed automatically, leaving the mind free for more important matters. The net result is a less mechanical existence, because it is less cluttered with the ever-recurring necessity of straightening out problems of routine.

Next, having rationalized his daily schedule of hours, an individual can devote his attention to methods of econo-

mizing on time during work hours. The following suggestions indicate phases of the work situation which can be studied for the purpose of saving time through better organization.

Spatial Arrangement of the Work Setting.—In the chapter on attention it was pointed out that a person can attend to more than one thing at a time, but only provided that all the things are unified by being combined into a larger, more inclusive whole. This tendency to try to bring unity out of diversity is so fundamental in thought and action that efficiency in performance can be improved by any kind of orderly arrangement of tools and setting which brings about a higher degree of unity. For example, the furniture in a work room or office should be placed with reference to a focal point which, being the region of greatest activity, necessitates the smallest number of steps from it to all other parts of the room. Consider the position of a desk in an office. Among the factors to be studied are the following:

Is it properly placed in relation to the best lighting, i.e., so that the person seated at it does not face the light but receives it over his shoulder?

Is it placed so that visitors entering the office will face the person at it, or must he swing completely around in order to talk to them?

Is it near bookcases, filing cases, supplies, so that a minimum of steps is required?

Material on or inside a table or desk should be so arranged that the ease of access to containers, drawers, and pigeonholes has some relation to the frequency of their use. The mere necessity of hunting for tools can consume an inordinate amount of time. See Plate 8. When a place has been chosen for a given article it should be consistently kept there, because the tendency to form position habits is strong. As long as things are in familiar places, much of the routine of

locating them is subconscious; no conscious attention is required; but when they are misplaced, all one's attention has to be diverted temporarily to locating them.

We can take a leaf from the book of the motion study experts on how to cut out all superfluous motions in executing the manual part of mental tasks. It is often advantageous to make a job analysis of one's habitual daily operations so that all non-essential duplicative actions can be detected and struck out. With such information at hand, a list of essential daily activities can be drawn up, and adequate but not excessive time allowed for them in a time schedule. Time can also be provided for the exceptional tasks that arise periodically. Otherwise one is constantly being caught off guard, with no time for unusual demands that arise suddenly.

How to Handle Interruptions.—If part of his job is executive in nature, one is sure to be interrupted frequently by persons who want all sorts of things, from advice or making complaints to companionship or sympathy. Hours of precious time can be taken up by people who really have no legitimate demand on one's attention. Often, however, the difficulty is that those who do have legitimate problems come at the most inconvenient times. It would appear that the administrative officer is at the mercy of those who make demands on his time and that a daily time schedule is out of the question for him. But even here, planning and organization can accomplish wonders. What are the main sources of difficulty?

First, the executive has his own work to do. This requires reasonably long periods of uninterrupted concentration, which he should be able to have.

Second, he must devote a certain proportion of his day to conferences. The time allotted would be sufficient if he could control their length and terminate them at will.

Third, he needs protection against illegitimate demands

on his time. One obvious device for this purpose is a secretary who is skilled in sorting out the important from the unimportant, and who can take responsibility for assigning future appointments at more convenient times. In the absence of such luxuries, he must work out as many rigid rules or practices as are required for dealing with typical cases. Some of these are suggested below.

To avoid being interrupted at inconvenient times, have definite hours for conferences and adhere rigidly to them. Inform other people about them so that everyone will know when you are available for consultation.

To control the length of appointments, have a stock method of terminating them, such as rising and offering your hand in a compelling handshake, or asking the person to return at another time. Ask long-winded people to submit their problem or proposition in writing.

To discourage mere time-wasters, resume working. If they fail to take this hint, begin working at some noisy job like typing. Few persons can go on talking above the din of a typewriter.

A little planning ahead of time can reduce annoyances and clear the way for needed periods of uninterrupted concentration. Fortunately, people who are frequently interrupted find that they can eventually adapt to interruptions, like distractions, so that they cease to destroy the continuity of thought.

Utilizing Slack Time.—When the order of our daily business is externally imposed instead of under our own control, we are likely to find ourselves swamped with work at one time and with time on our hands at another. Such periods cannot be anticipated. The remedy is to keep short jobs in reserve for such periods. Working on them may be nearly as restful, because of the change of work, as an actual rest period.

Economy of Ability

No one is equipped for every kind of job that arises in connection with his work day. It is uneconomical to try to do everything oneself. Some things can be delegated to others who possess specialized skills, and others can be handled by labor-saving gadgets, so that one is free to utilize his own abilities and skills to the utmost. There is a vast difference between delegating jobs merely to escape "dirty work" and delegating them to people who can do them better or more economically so that we can concentrate on the things we are fitted for. By economizing in this way, we can spend the necessary time in perfecting ourselves in the essential direction. The jack-of-all-trades is often the person who excuses himself for his failure to concentrate on essentials by filling his time with odd jobs.

Economy of Health

It is as uneconomical to spend energy lavishly in the present with no thought for the future as it is to spend money that way. It is a wise saying that "every man, by the time he is forty years old, is either dead or a physician." This originated in the days when expert advice on health was much harder to obtain than it is today. But it is still true that a man must be his own doctor when it comes to setting up and following a rational program of exercise, diet, sleep, and recreation. One frequently hears a busy man boast that he has not had a vacation in ten years. This is about as sensible as to boast that he has put no lubricating oil in his automobile since he bought it five years before. Sometimes people who go without vacations are merely suffering from emotional immaturity. Even if they do take a vacation their conscience

will not let them relax and enjoy themselves, either because they have fallen too deeply into the work rut or because they regret the money spent. The emotionally mature person does not allow his childish conscience to lead him around by the nose when its dictates are not in accord with what his mature judgment tells him is the best policy in the end. Recreation need not add much to expenses; it is the inexpensive kind that is most valuable.

Economy of Money

There are three excellent reasons for planning a financial budget. One is that peace of mind is essential to efficiency in work; no man can be efficient when he is constantly harassed by finances. It might be argued that merely putting down figures in a ledger does nothing to relieve the strain. This is not true. Worry is enhanced by uncertainty even more than by a knowledge of the worst. Another advantage of budgets is that they give a basis for redistributing one's resources in a way that will do the most good. The careful budgeter is like the general with a limited number of troops at his disposal who realizes that it is not so much the overall size of the army that counts as having it concentrated at the strategic point at the right moment. The third advantage of a budget is that it encourages the long-time point of view regarding finances. An adequate financial plan should not be for the week or month or even year, but for the lifetime. It should provide for vacations and for security after retirement, but at the same time it should prepare one to take advantage of sudden opportunities and to meet sudden emergencies. For this reason, a flexible budget is better than too rigid a program. In rapidly changing conditions such as we are passing through now, no mechanical system can take the place of wise individual planning.

Planning for Life

The most important kind of planning is that which envisages the individual's whole life. Every man and woman has a vague notion of what he wants to get out of life. Many would repudiate their actual goals, if they stopped and considered them frankly in the light of mature common sense, instead of allowing the wishful thoughts of youth to tyrannize over them. Life goals need to be taken out and dusted once in a while. As a man grows with the years, his life goal should grow with him. Below are some of the more important components of an adequate life plan. Although they relate to things outside of the work life itself, it is of course assumed that one's vocation is an intrinsic part of the plan. Everyone probably achieves most of these values in a haphazard way, but it is only by consciously organizing life with reference to clear-cut goals that the fullest satisfaction can be gained. William James gave a vivid characterization of the conflict that can occur in our internal life if we try to follow all the goals and ambitions that we happen to adopt at different periods in our development. As he put it, he would have liked to be a *bon vivant,* a great financier, and an actor, as well as a psychologist, but these goals were incompatible; to achieve peace of mind, he had to choose one and stick to it.

We might list the following as the essential components of an adequate life plan: friends, satisfying hobbies, a program of self-improvement, provision for retirement, and the building and maintenance of personal morale. In the case of people who are fortunate enough to have families, we would include the family as the sixth component.

Friends.—It is a fact that most persons acquire their friends in what seems to be a haphazard way. Planned friendships

seem to be an anomaly. But the truth is that the process involves much more deliberation than is evident on the surface. Friends are acquaintances who stick because they find mutually compatible interests. If our friends are to be permanently congenial to us and we to them, it must be on the basis not only of present mutual interests but of future goals. They and we must be moving in a similar direction; otherwise the partnership must eventually be dissolved. Hence there is nothing monstrous about planning our friendships and then deliberately cultivating them. They will have a great deal to do with directing the expansion or contraction of our own life.

Hobbies.—Hobbies range all the way from a serious avocation to the transitory interests and activities that enrich the leisure hours. The only requirement of the hobby is that it shall be followed because it yields solid satisfaction and brings relief and recreation from work. It is surprising how many men of humble vocation have become famous through their hobbies rather than through their vocations. For example, Charles Dickens was a clerk and reporter who took up writing at night after his monotonous day's work was done; Lewis Carroll, the author of *Alice in Wonderland,* was a mathematician by vocation; Gauguin, the painter, was a stockbroker; Robert Burns was a tax collector and farmer; Benjamin Franklin, a printer; and Eli Whitney, the inventor of the cotton gin, a school teacher. Lamb and Hawthorne, like Dickens, made their living by working as clerks. It is not so strange, after all, that a man should become famous through doing the thing he loves to do rather than the thing by means of which he supports himself.

From a psychological point of view, a hobby is valuable for a number of reasons. It is a means of relieving emotional tension. Persons with fascinating hobbies can always withdraw into themselves. They are not bored with their own

company; they seldom become neurotic. A second advantage is that hobbies offer an alternative trade or skill which can be turned to in hard times and made a source of income. In the depression of 1930 to 1933, many men were saved by their hobbies, whether they used them as a source of income or merely as "boondoggling." The man without any hobbies has nothing to integrate his leisure hours; he is compelled to throw himself entirely on the mercy of his family and friends, or else to seek transitory amusements on the outside. The most important contribution which hobbies can make is gradually to replace the strenuous life of social and physical activities engaged in by younger people. After a person reaches middle life, the opportunities for and the satisfaction from an energetic social and night life steadily decline and the importance of hobbies steadily grows with the years until, when the decisive break occurs at the age of retirement, they play the role of a paid-up endowment policy against the emotional unsettlement that would otherwise occur at this time. If a person waits until he reaches this time of life before developing a hobby and then frantically snatches at new interests, he is likely to be disappointed. It is at the transition point between active life and retirement that the difficult period is encountered. The man who enters retirement armed with one or more hobbies which have become lifetime habits will find it a period of deep satisfaction and contentment.

Self-Improvement.—Self-improvement here means something broader than was implied in Chapter XVI, when we discussed the need for perfecting one's work skills. We refer, rather, to the gradual broadening of one's horizon throughout life by reading, travel if one can afford it, adult education, attendance at informative lectures, and cooperation in community activities. The carefully planned life looks toward an ever-expanding personality. We cannot stand still

or slide along on our past efforts. From the moment we cease to grow, we begin to shrivel up. On the other hand, it is surprisingly easy to follow a progressive plan of self-improvement, once it is well launched. The program is carried along by its own momentum. If friends or family can be induced to participate, the pleasure is even greater; it is disappointing to find oneself outgrowing one's friends. As an example, consider tastes in reading, music, and art. A background of familiarity with these things during youth is the best guarantee of good taste later. But the person who lacks this background can grow into an appreciation and liking for the best merely by exposing himself to it, listening to people who already have a discriminating taste, and taking pride in his growing understanding. A certain psychologist, wishing to find out to what degree such tastes are matters of native endowment and to what degree they are based on experience, exposed a group of subjects to daily practice in listening to certain intervals which rarely appear in popular music but are used freely in sophisticated music. His subjects rejected the intervals as disagreeable at first, but he found that they soon experienced a change in the direction of a liking for them. The widespread American attitude has long been to reject the best in favor of the popular, on the ground that red-blooded masculinity has no place for refining influences. The defect in popular music is that it depicts such a limited range of moods and thoughts. The lament of the lone cowboy has its place, but a little of it goes a long way. Such music requires little exercise of the nervous system above the spinal cord, and leaves no residue of developed mental muscles, no sense of achieving. As we shall explain presently, one of the most important effects of a program of self-improvement is that it raise our morale.

Building Personal Morale.—There is one more element, besides those already discussed, which seems to be needed

to make the life plan complete. What it is depends on the individual. Although not all persons satisfy this need in the same way, the need itself is probably fundamentally the same in everyone. It is the desire for something outside oneself to anchor to, something bigger or broader to identify oneself with. To some people this means the church and formalized religion. To others it means identifying themselves with some type of public service program, working with an organization which offers them an opportunity to share in world betterment or community service. Still others look for a philosophy which can give them an adequate answer to the meaning of life. It is the urge which prompts some soldiers to give their lives cheerfully on the battlefield because they feel that they are thus making a small contribution to a cause that is bigger than they are. This need probably has the same underlying basis as the motive, previously discussed, that gives men the desire for a sense of personal worth. After all, the assurance of one's personal worth has to lie outside oneself, either in the good opinion of other people or in some abstract value with which one is identified. But the means, after all, is not so important as the end—the building and maintenance of personal morale.

Summary

Efficiency was defined as accomplishing the most with the least effort or resources. Accomplishment was interpreted to include long-time rather than immediate goals. Resources were analyzed into time, ability, money, and health; and methods were suggested for conserving each resource by careful planning which takes all of them and their interrelations into consideration. Finally, it was suggested that everyone ought to have an overall plan which extends over the whole life. The components of such a plan include and make

provision for friends, an avocation or a hobby that can stand the test of time, a program of self-improvement, and a sound foundation on which to build and maintain personal morale.

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Chapter XVIII

EFFECTIVE THINKING

"Tho' man a thinking being is defined,
Few use the grand prerogative of mind;
How few think justly, of the thinking few!
How many never think—who think they do!"[1]

A BOOK on the psychology of efficiency would be incomplete without a discussion of the principles which make for efficiency in thinking itself. There is no single way of thinking, as there is of driving an automobile; there are as many specialized procedures as there are types of problem to be dealt with. But all of them contain certain basic principles which are essential to effective as opposed to ineffective thinking. To a certain extent, learning how to think soundly is a matter of learning to recognize the most common pitfalls in thinking. We shall be concerned with the following topics in this chapter: first, the nature of thinking in general, an analysis of what it consists in; second, an identification of the kinds of error in thought which result from emotional and cultural biases; third, a brief survey of the commonest logical fallacies in thinking; and, fourth, suggestions for sharpening the accuracy of thought by the application of some standard procedures.

WHAT IS THINKING?

We can dismiss at once the aimless type of thinking which all of us indulge in when we are not using our mental proc-

[1] E. L. Clark, *The Art of Straight Thinking*. New York, Appleton-Century, 1929. P. 1.

esses for the accomplishment of any end, the kind that makes it difficult or embarrassing for us to answer the challenge, "A penny for your thoughts," because we realize that this to too high a price to pay for the jumble of disconnected thoughts that fill the vacant moments of the mental life. These are little more than wish-fulfilling daydreams and reflections of the emotional attitudes of the moment. Excluding this type at the outset, we find that all thinking is problem solving and consists in the following stages:

The Existence of a Problem.—The problem may be a theoretical one, as it is in reflective thinking, or it may be a practical one, as when our automobile stalls on a country road, or when we must decide whether to drop a life insurance policy to secure enough cash to meet a financial emergency. The problem always consists in the need for discovering a new mode of procedure because the procedures immediately at hand are inadequate.

Suggestions as to Possible Solutions.—When a person confronted with a difficulty begins to think intensively about it, he gets a number of vague hunches about solutions or partial solutions. Most of them are wrong or incomplete; he cannot know, before he actually tries them, which is most likely to succeed. For example, when the automobile stalls, the driver thinks to himself, "It might be that the spark plugs are fouled with carbon, or it might be that the coil has got wet, or it might be a leak in the gas line, or perhaps the tank is empty."

Trying Out Several of the Possibilities.—The possibilities can be tried out in two ways: either physically, or mentally, to save time and shorten the process. For example, the driver of the car may get out of his seat, go to the front of the car and raise the hood, and begin to tinker with the various parts until, by chance, he finds a loose wire or something else that explains the stalled engine. Or he may remain in his seat

and think over the various possibilities, considering the reasonableness of each one, and all the known facts which bear on the matter, until he is quite sure he has hit upon the correct alternative. Thus he will take into consideration the sound made by the engine when it stopped, whether it was a loud explosion, a slow fizzle, a series of jerky jolts; he will consider how long it has been since he last filled the gas tank, and the like.

The Acid Test: Solution of the Problem.—The final step is to apply the preferred alternative to the situation and see whether it actually solves the problem. If so, the practical process is complete. If not, further "trial-and-error" thinking must be done; new hunches may appear and they will be tested until success is achieved. One idea leads to another; a wrong hunch can lead to a whole series of false inferences, just as a right one can lead to other right ones and shorten the process.

Generalizing.—In theoretical thinking, and often in the practical type, there is a final step. This consists in seeing the application of the particular solution to a whole range of similar problems. This is the process of generalizing, and it results in the setting up of a general rule of procedure, or principle. Effective thinkers always generalize, so that they have only to solve one of a class of problems in order to be prepared to meet all the others as they arise. This is the gist of the saying, "A wise man never makes the same mistake twice."

What Mental Processes Are Involved in Thinking?

Let us now break down the process of thinking still further in order to determine what makes the difference between effective and ineffective thinking. Several processes enter into it; any one of them may be inadequate and

thereby destroy the validity of the whole procedure. The good thinker is one who has developed each one of these processes to the highest degree. They are: *observing* accurately; *selecting* the essential features; *organizing* knowledge for effective retention by *relating* it to the whole body of one's systematic knowledge; *retaining* it; and having it in readiness to *apply* to the situations it fits. We shall consider the factors which tend to make each one of these processes effective.

Observing Accurately.—Accurate observation enters into every step of the problem-solving activity, but it must have taken place in large part before the particular problem even arises. It must be a habit of mind, so that many accurate observations made over a long period of time can be brought to bear on the present problem. For example, an automobile driver who has never noticed the various sounds a car makes when different things are wrong with it, who has never realized that spark plugs get fouled with carbon, who has never noticed where the coils are located—such a driver could not possibly engage in an effective "trial-and-error" process of reasoning when an emergency arises. A good observer is constantly storing information; his observations are always pointed and purposeful; he focuses attention on essentials, even when there is no particular problem, because he has formed the habit of analyzing things in order to understand them. One of the mental characteristics of a good observer is openness of mind. The person with a closed mind approaches every situation with preconceived ideas about it; he does not bother to correct false opinions or false impressions by careful check-up observations. He is happier to trust his preconceived notions than to find out the real truth. For example, if he made a trip to England, he would return with reports that Englishmen cannot see a joke, that they are natural servants, etc. He would have seen exactly what he ex-

pected to see, no more and nothing different. This is not true observation at all.

Another requirement of accurate observation is the making of fine discriminations. The writer once taught in a large building which had seven large pillars in front, and all of his class of six hundred students passed under those pillars every day in entering the building. Yet, when asked how many pillars there were, less than 10 per cent of the class answered correctly. Why? Because they had never counted them. Observations are never accurate, they are never more than vague and sketchy, unless they are reduced to quantitative terms. Suppose there is an automobile accident and you, a witness, are called upon to testify. Can you state how fast the car was going just before the crash? Have you built up a habit of making accurate estimates of the speed of moving bodies? If not, your vague impressions will probably be wrong. Consider the contrast between unscientific and scientific observations. The following are unscientific observations:

If it rains before seven, it will stop before eleven.

Red at night, sailors' delight;
Red in the morning, sailors take warning.

Unscientific observations are characterized by the tendency to draw conclusions from too few instances, to disregard contradictory evidence, to be overly impressed by a few striking instances, especially if they support one's belief, and to fail to distinguish between what is essential and what is merely fortuitous. Scientific observations are characterized by the practice of paying attention to only one factor at a time, studying it under a variety of conditions, repeating observations again and again to make certain and then carefully recording the quantitative findings, and suspending judgment until all the evidence is in, before coming to a final conclusion.

Selecting What to Retain.—It is as important to know what to forget as to know what to retain. The good observer always approaches situations with hypothetical problems in mind. Everything he notices is fitted into a framework of useful information to be drawn on later. He discards useless facts so that his memory is not overburdened with them and he can concentrate on the useful ones. Consider such a commonplace event as reading the newspaper. Suppose you have only a half hour in which to read it. Your main purpose is to keep informed as accurately as possible on current events. You decide to concentrate on three things—foreign news, national news, and local news—allowing ten minutes for each. It is difficult for a novice to do as good a job as Kaltenborn or Swing, for their selection is guided by an intimate knowledge of foreign countries. But you can use certain principles of selection. Headlines are unsafe guides. The headline writer is more interested in selling papers than in informing the public. Furthermore, the body of the article usually disputes the headline. You must glance through the article, seize on the salient points, and fix them in mind. Much detail will be deliberately rejected in the process. Perhaps from one article telling of Russian successes you form a tentative opinion, "The Axis is collapsing." But you are not satisfied with a snap judgment like this, so you select one or two other articles for verification. In hunting about, you have been deliberately ignoring a mass of material that has mere curiosity value and with which the average reader crowds his mind. Ask that average reader what the news is, and he cannot give an intelligent answer, even though he may have pored over the paper for a couple of hours. He is like a child who stuffs his stomach with odds and ends before a meal and has no room left for the meat course.

Organizing and Relating.—New knowledge must be fitted into a framework before it is available for use. Facts

must be related to other facts and placed in their proper setting. It is doubtful whether there is any such thing as sheer retentiveness, in the sense of the ability to remember impressions that are devoid of any significance whatever, merely by repeating them over and over. We always remember by relating, by associating facts with other facts. The first step is *classifying*. For example, suppose you must remember the names of the states in the United States. There are 48 of them and that number of single items is too great to fixate. But if you divide them into the New England States, the Southern States, the Middle-Western States, the Northwest States, and the Southwest States, the task is much easier. Classification should always be in terms of use, not merely artificial. Thus listing together the states beginning with A and those with B, etc. would achieve no good purpose. There should be enough classes to cover the data. Such snap methods of classifying as calling all voters either radical or conservative merely cover up the important groups who refuse to be pigeonholed in either of these categories. On the other hand, all the classes included in a given group should come under some one common principle. There should be no overlapping of classes, such as classifying Arizona as both a southern and a southwestern state in the example used above.

The second step is *evaluating*. Facts are never complete. They are always fragmentary, partial. But if they are carefully chosen, they can be representative; that is, they can constitute a fair or adequate sample that shows the true state of affairs. For instance, a fair and properly selected sample of the opinions of the people in the United States on a political issue can be obtained with ten thousand persons; this will give a true indication of the trend. On the other hand, a sample based on the opinions of ten million can give a totally erroneous impression if they are improperly selected so that excessive weight is given to one faction. Thus if the ten mil-

lion are all from the Southern States, their opinions will tend to conform to those of the conservative democrats. If, on the other hand, they are all from the Northeastern States, they will express the industrialists' opinion, not the farmers'.

Evaluating Secondhand Information.—Part of the trick of securing accurate information from secondhand sources is to be able to judge the value of the sources. The cartoon in Plate 9 illustrates the point. We must be sure that the evidence is competent; that is, it must be given by those who have had firsthand opportunity to know the facts, rather than voicing mere authoritative opinions; it must not represent personal biases or prejudices which have blinded those who give it to the truth; it must be corroborated by other competent sources; and it must concern things which are factual in character and not matters of opinion. If the sources are written documents, newspapers, magazines, and the like, they should be firsthand, not copies from other primary sources, because local prejudices can distort such evidence. Newspapers are notoriously unreliable and biased, particularly about political matters and those which might affect their advertisers' reputations. Magazines are usually propagandists for a particular point of view; they are either very conservative and opposed to anything threatening the *status quo* or very radical and contemptuous of existing conditions, or they appeal to and try to please a certain limited group.

Fully as important as the necessity of being critical of the secondary sources of our information is the necessity to guard against our own interpretation of what we find in the sources. There is a strong tendency to reject evidence that is contrary to our preconceived beliefs and to accept evidence that corroborates them, even if the source is reliable. For example, the dictionary is a fairly unprejudiced source of information; but a person who wants to justify a particular pronunciation of a word can usually do so, even though he

must neglect alternative and perhaps preferred pronunciations.

Formulating Conclusions.—The next step, after the evidence has been gathered and organized, is to draw the inferences which will aid in the solution of our major problem. This procedure may take one or both of two different forms. It may involve generalizing from factual data, formulating a general principle, as when our visitor to England decides, "It is not true that Englishmen can't see a joke"; or it may involve applying a generalization to the case in hand, as when our traveler decides that it will be a good policy to introduce a few jokes into a radio address to be broadcast to an English audience. The first form of inference is called *inductive,* because it draws a general conclusion from many particular instances; the second is called *deductive,* because it derives an answer to a particular situation from a more general principle which has previously been established. Sometimes both enter into the process of thinking, as when a person must first discover or verify the general principle before he is ready to act on the particular conclusion which he derives from it. It is sometimes necessary, in the process of establishing a general principle, to deduce a number of particular instances of it and test them one by one. If the particular instances result as expected, the general principle is verified.

Reasoning Versus Rationalizing

It is at this point in the thinking process, the point at which conclusions are drawn from evidence, that an important warning must be sounded. There are two different ways in which people actually proceed, which are as far apart as the poles. One way is rightly called reasoning, because its purpose is to get at the truth, whether the truth is pleasant or

unpleasant, whether it fits our prejudices or goes directly against them, whether it helps or hinders our cause. This procedure is rare. The other way is frequently mistaken for reasoning both by those who use it and by those who are misled by it, but it is utterly different. The name given it is "rationalizing," but this does not suggest anything to our minds; we must further describe the process. Rationalizing consists in finding justifications for a belief which we have already adopted or a course of action on which we have already decided. For example, psychologists in this country have made many studies of the average intelligence of different racial groups and have come to the conclusion, on the basis of all the evidence, that there is probably no such thing as a race whose stock is definitely inferior to other races, nor is there any such thing as a superior race. This was arrived at by reasoning. In Germany, however, a directly opposite conclusion was reached because the process used was rationalizing. For political reasons, the Germans wished to conclude that certain races were inferior. Therefore, they drew the conclusion that fitted the wish rather than the one that best fitted all the facts impartially surveyed.

Many of the beliefs and judgments in terms of which we carry on our thinking are based on the previous rationalizing of ourselves and others, so that we cannot think straight and draw correct inferences because our premises are false. Among the common fallacies that are widely believed and that have great influence on people's thinking and acting are the following:

There always has been war and there always will be.

All that business needs is to be let alone.

Man has five senses, plus a sixth one that warns him of emergencies.

If a man uses his will power he can overcome a bad heredity and a bad environment.

The shape of the head and the expression of the face give a reliable index to a person's intelligence.

Brilliant children drop below average when they grow up.

Colds are caused by getting cold.

Red-headed people have fiery tempers.

This list could be extended indefinitely. The author of the "Debunker" column in the daily papers has found enough fallacies in popular thought to keep his column going for several years. A good way to start, in clarifying our thinking, is to throw out a lot of the rubbish that we have carried along from childhood, and from which we have drawn conclusions in guiding our conduct.

Common Fallacies of Inductive Thinking

It is beyond the scope of this book to go deeply into the processes of inductive or deductive logic. We are interested in these processes as they are used informally by everyone, without being identified as such. Some of the most common pitfalls of inductive thinking are as follows:

1. Assuming that facts which are correlated must be causally related. If two different sets of facts seem invariably to accompany each other, so that every time one set varies the other set also varies, we have a basis for assuming a possible causal relation but we have no sure proof of it. For example, a certain investigator set out to discover whether smoking affects intelligence. He examined all the boys in a certain high school to find out whether they smoked and how it affected their grades. He found that the boys who smoked always had lower grades than the non-smokers, whereupon he concluded that smoking stunts the growth of intelligence. But there is good reason to doubt the truth of his conclusion and to suspect that both the low grades and the smoking

were due to a third factor, namely, fraternity membership. The boys who smoked belonged to fraternities. They were also the ones whose social activities interfered with their study. This, not the smoking, was the likely cause of their low grades.

2. Assuming that what has not been proved false is therefore true. It is a wrong use of the inductive method to assume that failure to find negative instances establishes the truth of a thing; perhaps it has never been put to a crucial test. No one has bothered to prove the falsity of numerology; but this certainly does not establish its truth for it would be a simple matter to find negative evidence. Fortunately the courts assume that a man is innocent until he has been proved guilty. They do not assume that, because he has not been proved innocent, he is therefore guilty. In our private thinking we constantly indulge in this fallacy. If gossip has it that John Doe beats his wife, we accept it in the absence of contrary evidence, and we even suspect there is something wrong with such evidence when it does appear. This fallacy is often brought out in defense of old doctrines and beliefs, the argument being that they have stood so long without disproof that they must be true. One should be wary of such an argument.

3. Assuming that what is true of a given thing is therefore true of anything else that resembles it. This is the method of reasoning by analogy. There is nothing wrong with this method if it is understood and properly safeguarded. But it is usually used in a totally erroneous way. For example, consider the following:

> Sick people remain in a hospital until they are cured.
> Criminals are morally sick people.
> Therefore they should be given indeterminate sentences.

The fallacy lies in the analogy between physically sick and morally sick. We know a great deal about the one and prac-

tically nothing about the other; hence we have no reason to assume that they are alike in anything more fundamental than the name we have given them. Here is another example:

My budget calls for some money to be spent on recreation.
Gambling is my recreation.
Therefore I am justified in spending money on gambling.

Arguments from analogy are valid only when the following facts are true of the two items which are being compared; they must have numerous points of resemblance which are real, not artificial; basic, not superficial; and they must have no point of crucial difference.

Common Fallacies of Deductive Thinking

We recall that deductive thinking is the process of deriving a particular conclusion from a broad general principle by showing that if the case in question comes under the general principle, then the particular conclusion must follow from it. When these steps are put down in formalized order, they constitute what is called a syllogism. For example:

All interruptions of production in war time are bad.
Strikes interrupt production in war time.
Therefore strikes are bad.

There are three propositions; the first is the general principle, called the major premise; the second is the particular case in question, called the minor premise; the third is the conclusion. The whole syllogism can be reduced to a skeleton by substituting letters for the terms involved, as follows:

All X is Y		(major premise)
Z is X		(minor premise)
Therefore Z is Y		(conclusion)

Here X stands for "interruptions of production in war time," and is called the middle term because it appears in both major and minor premises; Y stands for "bad," and is called the major term; and Z stands for "strikes," and is called the minor term.

If the word "all" occurs at the beginning of the major or minor premise, the premise is universal. If the word "some" is used instead, then the premise is not universal but particular. This is mentioned because the same rules cannot be applied to these two different types; therefore we must be wary of treating particular premises as though they were universal.

Another thing to notice is that propositions can affirm or deny something. This creates the possibility of negative syllogisms like this:

No X is Y	No non-citizen is a voter.
Z is X	Aliens are non-citizens.
Therefore no Z is Y	Therefore no alien votes.

But we have to avoid making the following false inference:

All X is Y	All voters are subject to the draft.
and no Z is X	No aliens are voters.
Therefore no Z is Y	Therefore no aliens are subject to the draft.

The point is that the major premise does not say that the voters are the only ones subject to the draft.

There are a large number of fallacies in thinking that relate to the internal structure of the syllogism, the arrangement of terms and premises. However, a discussion of them is beyond the scope of this book; it can be found in any book on logic. But there are other types of fallacies that are very common in thinking which do not depend on technicalities of the syllogism but on other factors. They are worth discussing in a chapter on efficient thinking.

To go back to the first example, the one about strikes. It is perfectly logic-tight, and a good syllogism; yet many people

e justified in refusing to accept the conclusion be-
:y would not agree to the original assumption from
ıe reasoning proceeds. They would deny that any
y interruption of production in war time is, in every
ıad thing. This leads us to formulate the first com-
acy in deductive thinking.

'alse Premise.—A false premise leads to a false con-
even if the logical process is correct. This is probably
he most dangerous sources of error in thinking, be-
e very clearness of the logic gives us a false sense of
and blinds us to the shakiness of the original as-
ns on which the whole process hangs. Consider the
ıg:

wrong to take life.
ɔldier must take life.
:refore it is wrong to be a soldier.

he propositions are set out in a clear form like this,
er to see where the difficulty lies. But we usually slur
: terms and conceal the false assumption. Consider a
ıt like this: "I knew when I hired Jim he would be
cause he was a colored man." This statement might
ıallenged as it stands, but the false premise will be
zed if the steps are set forth clearly as follows:

colored men are lazy.
ı is a colored man.
erefore Jim is lazy.

nes it is not the general principle (major premise)
particular case (minor premise) that is false. Under
rcumstances, the conclusion will be false. Here is an
e:

minals should be punished.
ɔoteurs are criminals.
erefore all saboteurs should be punished.

: second statement (minor premise) that many would

deny if they stopped to think that the United States uses saboteurs as well as the enemy.

Question Begging.—Begging the question is a very common error in deductive thinking. It has a number of different forms, one of which is called "reasoning in a circle." Consider the following statement: "Capital punishment is wrong because it is wrong to take life." This is no argument; it is merely repeating over again what was already said. It is equivalent to saying, "Taking life is wrong because it is wrong to take life."

Reaching an Irrevelant Conclusion.—"Professor, I should get a good grade because I studied so hard." The grade is based not on the amount of study but on results. "We shouldn't help Britain because she burned our capitol in the War of 1812." Ancient history has little bearing on present conditions or policy. "John Smith should not be elected President because he has Indian blood." What bearing has this fact on his ability to discharge the duties of this office? "To change the Constitution would be to violate the sacred memory of Washington." How do we know what those whose memory we hold sacred would say if they were alive today?

Ambiguity in Terminology.—So often an argument hinges on a slight shift in the meaning of some word that is overlooked. The absurdity of the following argument depends on the double meaning in the words "work" and "labor":

All activity that is not play is work.
Schoolwork is not play.
Therefore it violates the laws against child labor.

Imperfect Disjunction.—There is a strong tendency to think in terms of exclusive categories; we like to fit things into opposed pairs of classes. Thus people are looked upon as being either good or bad, wise or foolish, conservative or

radical. We seldom recognize the possibility of more than two classes or of any intermediate degrees. This results in the error of reasoning called the imperfect disjunction. For example, consider the following:

A man was found with a bullet through his head.
He was not a suicide.
Therefore he must have been murdered.

Here the reasoner was trapped by this tendency to think in terms of exclusive pairs; it blinded him to the other possibilities, such as accidental death.

Conditional Premises.—It is a common procedure in thinking, especially when we are dealing with circumstantial evidence, to set up conditional premises. For example, we often reason as follows:

If Japan were planning to bomb Alaska, she would seize Kiska.
She is planning to bomb Alaska.
Therefore she will seize Kiska.

This is legitimate reasoning, because the second statement confirms the conditional proposition with which we started, i.e., If Japan were planning to bomb Alaska. But suppose we had said

If Japan were planning to bomb Alaska, she would seize Kiska.
She did seize Kiska.
Therefore she is planning to bomb Alaska.

This is faulty reasoning, because our conclusion assumes that the only reason for seizing Kiska is to bomb Alaska, and the first proposition did not make any such assumption.

Rules for Effective Thinking

We are now in a position to summarize this chapter by setting down a list of mental attitudes which promote, and a list which hinder, effective thinking.

AIDS TO EFFECTIVE THINKING

A clear-cut analysis of the problem to be solved
An adequate fund of accurate information to work from
An open attitude toward all reasonable hypotheses
A willingness to try out promising leads thoroughly, gathering all the added factual data necessary, and refusing to accept incomplete information
Suspended judgment until proof is reasonably sure
Alertness to recognize significant relationships
Skepticism regarding secondary sources of information until their validity is established
An examination of each of the steps in inductive or deductive reasoning to be sure none of the common fallacies has been committed

HINDRANCES TO EFFECTIVE THINKING

Letting yourself be guided by your prejudices and biases
Neglecting evidence which fails to support your theory
Being determined to win your point at all costs, rather than get at the truth
Never questioning the soundness of your own opinions
Accepting without question the authority of written and other secondary sources if they "are on your side"
Jumping at conclusions, and, having adopted an opinion, taking it as a personal insult if anyone questions it.

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GLOSSARY

abulia. A chronic state of indecision. Inability to come to a decision or initiate voluntary action.

achievement test. A test designed to measure the progress which a person has made in mastering anything to be learned, such as typing.

action current. An electric current which accompanies activity in a nerve, muscle, or gland.

action potential. *See* action current.

adaptation. Any change in an organism, in either form or function or activity, which renders it better able to maintain life under given environmental conditions.

adrenals. A pair of endocrine glands lying on or near the kidneys, one part of which secretes a hormone called adrenin which reinforces visceral activity in emotions.

alkaline reserve. A chemical state of the blood. When the alkaline reserve is high, the organism's energy is stored for effort; when it is low, the energy is deficient.

alpha waves. The type of brain waves having the greatest amplitude and lowest frequency, i.e., about 10 per second.

anoxemia. The condition resulting from an insufficient supply of oxygen to the blood stream.

aptitude test. A test designed to measure a person's capacity to profit by training in a specific activity, such as mechanics or music.

aspiration. *See* level of aspiration.

associative bonds. Connections between neural impressions which account for habits, memory, and the association between ideas.

associative interference. Interference with the operation of associative bonds in recall, due to the arousal of competing associative tendencies.

atrophy. Deterioration because of lack of exercise or use.

attention. A set, attitude, or adjustment of the organism which makes it better able to respond to a given stimulus.

attention wave. Periodic change in the level of attention, from high to low.

attitudes. Muscular postures, or mental sets, which prepare a person to respond in a particular way.

automatize. To make automatic so that conscious attention is no longer necessary.

autonomic nerves. The system of nerves which stimulate the smooth muscles and glands. There are two divisions: the sympathetic, which functions chiefly in emotions, and the parasympathetic, which functions mainly in vegetative activity.

autosuggestion. A suggestion which a person gives himself either consciously or subconsciously.

behavior. A term used in psychology to designate all the responses which a person makes to stimuli.

biological drives. Hunger, sex appetite, need for rest, shelter, and the like.

blocking or blocks. Enforced pauses in continuous performance occurring from one to five times a minute, and occupying the time of two or more average responses.

boredom. The subjective feeling accompanying mental work which is uninteresting because of monotony or the inadequate motivation of the worker.

brain anemia. Condition of the brain in which its blood supply is reduced in volume or richness.

brain center. May refer to the cerebrum, the highest brain, or to one of the lower centers in the brain stem.

brain waves. Rhythmic electrical impulses arising from the neural centers within the brain.

calorimetry. *See* respiratory calorimetry.

cathode ray oscillograph. *See* oscillograph.

central nervous system. The brain, brain stem, and spinal cord.

cerebrum or cerebral hemispheres. The highest brain, which functions in thinking, memory, and voluntary behavior.

climacteric. The abrupt change which occurs in the physiological state in late middle life. In women it is associated with the menopause.

closure law. The principle in Gestalt psychology which refers to the fact that incompleted tasks create a mental state of tension or suspense until they are completed.

color-naming test. A mental task consisting of calling out the names of colored stimuli as rapidly as they are presented in random serial order.

conditional premise. A major premise which contains an "if" clause, like the following: If a gun had been fired we would have heard the shot.

conditioned response or reflex. A response, which could originally be called out only by a certain stimulus, that becomes connected by conditioning to a new stimulus.

conditioned stimulus. The new stimulus which can excite the response after the conditioning has occurred.

conflict. A blocking or interference with performance due to the competition arising between two or more incompatible response tendencies.

correlation. The tendency for two things to be related in such a way that paired values of them tend to vary concomitantly.

crest. The high point of a wave, or wavelike variation, in a continuous line graph.

criteria. Standards by which variations in a given thing can be measured. Thus, speed and accuracy are criteria for measuring variations in efficiency.

cyclothymic. The type of temperament which shows unexplained ups and downs of mood.

decibel. Unit for comparing two different energies of tonal stimuli.

decrement. Decrease of efficiency of any activity as a result of its continuous exercise.

deductive thinking or reasoning. The reasoning process which starts with a general proposition and draws a particular inference from it.

deformation method. The method of measuring the amount of tension in a muscle in terms of the movement of a lever pressed against the muscle.

delta waves. Large brain waves of low frequency occurring in sleep, etc.

depolarization. Loss of polarity.

discrimination. Perception of difference between any two things in respect to certain characteristics.

disruptive. Tending to disorganize responses or activities which are taking place.

distraction or distracter. Any stimulus or process which decreases the attention being given to a particular task or response.

diurnal variations. Variations in performance or bodily state occurring during the twenty-four-hour period which tend to recur every twenty-four hours.

dominance. The trait which makes a person desire to control the actions of others. Same as ascendance.

drive. Internal source of stimulation giving rise to behavior appropriate to its satisfaction, such as the hunger drive or the desire for power.

dynamic. Tending to release energy.

dynamometer. An instrument for testing the strength of grip with the hand.

electrical potential. Degree of electrical discharge.

electrical skin resistance change. *See* galvanic skin resistance change.

electrode. A device used to join an electric current to some substance regarded as non-electrical in nature, such as the body or a part of it.

electro-encephalogram. The graphic record of brain waves obtained by placing electrodes outside the skull at two widely separate places.

emotional instability or irritability. The tendency of a person to be easily upset emotionally.

encephalogram. *See* electro-encephalogram.

end spurt. An increment in efficiency that appears in the work curve just before the end, when the approach of the end is anticipated by the worker.

endocrine glands. Organs of secretion which form a specific sub-

stance, called a hormone, and discharge it into the blood stream to be carried to all parts of the body, there to act on other organs.

energy level. The general level of nervous energy at a given time.

energy release. The process of making nervous energy available for use in behavior.

equilibrium. Maintenance of the body's balance against gravity while standing or sitting.

erg. The physical unit of work, in terms of mass, distance, and time.

ergogram. The record obtained from an ergograph.

ergograph. An instrument for measuring and recording the work done by a single muscle or set of muscles.

excitation. The process initiated in the nervous system by a stimulus.

excitation level. The amount of nervous excitation in the nervous system at a given time.

exhibitionism. The tendency or desire to show off mentally or physically before others.

external stimuli. Stimuli that act on the external sense organs of vision, hearing, touch, smell, and taste.

extrovert. An individual who manifests more intense interest in other persons and in objective events than in himself and his own thoughts. Opposite of introvert.

facilitation. The process by which any activity is reinforced, made easier, or increased.

facilitator. Any agent which produces facilitation.

fatigue. A decrement in output, feeling-tone, or bodily condition which results from continuous work and which is recoverable from by rest.

fatigue curve. A graphic representation of the level of performance from unit to unit of work in a continuous period of work.

fatigue products. Waste products resulting from the increased energy exchange during work, such as carbon dioxide, lactic acid, etc.

feeling-tone. A person's affective state at a given time, whether

pleasant or unpleasant, buoyant or depressed, refreshed or weary, interested or bored.

figure analogy test. A test in which each problem presented to the subject consists of seven figures; the first is always related to the second in the same way that the third is related to one of the last four. The subject must determine which of the last four is the correct one.

fixation. The process of learning a habit or memorizing material.

fluctuations. Regular or irregular variations from moment to moment in some process like attention or output.

frustration. A term used to designate the state of mind resulting from being blocked or prevented from achieving a goal.

galvanic skin resistance change. The change in skin resistance to the passage of a weak electric current through the body, due to physiological reactions of the sweat glands in emotion and thinking.

galvanometer. An instrument for determining the changes in the electrical resistance of the skin.

habit pattern. A well-learned pattern of activity resulting from previous performance.

hallucination. An experience of subjective origin which is mistaken for a real perceptual experience by the one having it.

histological. Pertaining to the microscopic structure of body tissues, such as nerve tissues.

homogeneity. The quality of sameness resulting from the repetition of one or a few elements.

hyperkinetic. Overactive. The direct opposite of hypokinetic.

hypertension. An excessive degree or amount of tension in the body muscles; not to be confused with the medical term vascular hypertension.

hypnosis. An artificially induced trance-like state that is characterized by increased suggestibility as a result of which certain abnormal sensory, motor, and ideational reactions can be obtained.

hypochondriac. A person who imagines he has all kinds of diseases because he exaggerates slight symptoms.

ideomotor action. Response which follows thought process di-

rectly, often without the intervention of deliberate voluntary intention to respond.

imperfect disjunction. A proposition in which the two alternatives given fail to exhaust all the possibilities. Thus: either it rains or the sun shines.

incentive. Some stimulus object outside the individual which appeals to one of his motives and leads him to put forth effort to secure it.

incipient response. The beginning of an act which may not go beyond the initial stage.

increment. A measured increase in something, such as an increment in output. The opposite of decrement.

indirect suggestion. *See* suggestions. Suggestion is indirect when it is implied rather than stated or presented as such.

inductive thinking or reasoning. Reasoning from particular instances to the formulation of a general truth or principle.

inhibition. Interference with the occurrence of a nervous or motor activity due to some other physiological process.

initial spurt. A high initial level of performance from which there is a drop.

insomnia. Inability to sleep, real or imagined. Experimental insomnia is voluntarily undertaken.

integration. The bringing together of part processes to form a unitary whole.

integrative process. *See* integration.

intelligence quotient. The ratio resulting from dividing the mental age by the chronological age.

interest analysis test. *See* vocational interest test.

interpolated. Introduced between two activities or points.

intrinsic. Having to do with the thing itself rather than its relations to other things outside it.

introspection. The process of observing one's own thoughts or experiences.

introvert. A person who is more interested in his own thoughts and experiences than in other persons or things about him.

irrelevant. Not pertaining to the task or thing being attended to at the moment.

learning curve. A graphic representation of the progress made in learning something with each successive equal unit of practice.

level of aspiration. The level of performance which a person would like or intends to attain.

major premise. In a syllogism, the proposition which contains the general truth from which the particular inference is deduced.

mental age. The age assigned to a given child in accordance with the level of difficulty of the questions in the Binet Age Scale that he can answer. A child who can just answer the questions that the average seven-year-old can answer is said to have a mental age of 7.

mental function. Sensation, perception, reasoning, memory, emotion, etc.

metabolic rate. The rate at which metabolism occurs.

metabolism. The chemical changes in living cells by which energy is provided for bodily activities and waste is repaired.

minor premise. In a syllogism, the proposition which introduces the minor term. It is the second proposition.

mobilizing energy. The process of making available for a given activity all the organism's energy at the time.

motility. The trait which causes a person to be active or to desire to be active.

motive. Impulse to action initiated by internal needs or drives, like hunger, sex, or desire to achieve a goal.

motor impulse. A nervous impulse which initiates some movement or muscular response.

native ability. Ability conceived of as determined by hereditary factors.

negative suggestibility. Tendency to respond negatively to suggestions.

negative suggestion. Suggestion to do the opposite of the action desired.

negative transfer. *See* transfer. When the effect is to inhibit the ease of learning, rather than to facilitate the learning of the second habit, the transfer is negative.

negatively accelerated. Showing a decreasing rate of improvement in a function as a result of successive added units of practice.

nerve centers. Centers where nervous impulses are redistributed.

nerve impulse. The current which travels along a nerve fiber when the nerve is stimulated.

neural arc. The entire nervous pathway from a sense organ to the brain center and out again to a muscle or other responding organ.

neural channels. Pathways along which nerve impulses are discharged.

neurasthenic. Suffering from a mild state of nervous exhaustion.

neuromuscular. Involving a muscle or group of muscles and the motor nerve or nerves which activate them.

neurosis. One of a class of mild mental disturbances of emotional origin.

neurotic. A person constitutionally affected with a minor nervous disorder.

numerical ability. The ability to manipulate numbers and quantitative concepts readily.

objective. Capable of being studied by external observation or with physical instruments; opposite of subjective.

oscillograph. An instrument which produces a visual record of the wave form of electrical oscillations.

overt. Externally observable; opposite of implicit or internal.

oxidative process. The process by which oxygen unites with the materials of the cells in producing energy.

oxygen debt. When the oxygen is used up faster than it is supplied, a debt accumulates which must be made up later.

percentile. That point below which lie a certain percentage of the cases in a distribution of scores. Thus the 50th percentile is the point below which half the cases lie.

perception. Direct awareness of external objects as a result of information conveyed through the sense organs.

periodicity. Recurrence of anything at regular intervals.

perseveration. The tendency for a feeling, idea, or action to continue or to recur without voluntary effort or intention.

plateau. A temporary halt in the progress of learning during which added units of practice bring no improvement.

point score. A score stated in terms of the number of points gained, questions answered correctly, etc., rather than in terms of mental age, percentiles, or standard deviations.

polarity. State of having a positive and negative pole.

positively accelerated. An increasing rate of improvement in some function as a result of added practice.

primary ability. One of the main groups of abilities that make up general intelligence. Numerical and verbal ability are examples of primary abilities.

proprioceptive system. *See* proprioceptors.

proprioceptors. Sense organs located in the muscles, joints, and tendons which are stimulated by movements of the limbs or contractions of the muscles.

psychasthenia. A type of neurosis characterized by morbid anxiety, fixed ideas, etc.

psychic. Synonym for mental.

psychic tension. A mental state of suspense tending to motivate a person to finish an incompleted task or pattern.

psychograph. A graph made by plotting a person's score on several different traits at once, arranged in parallel order, and connecting the points by a continuous line. Also called profile chart.

psychophysics. The branch of psychology which studies the relation between variations in subjective experience and variations in the objective stimulus.

psychotic. Having one of the serious mental derangements.

quantitative ability. Ability to think in terms of numbers and other quantitative concepts.

question-begging. Anticipating the conclusion in the premise.

questionnaire. A blank containing a series of questions which the person checks as being descriptive of him or not.

rationalize. The term has two meanings: (1) to make logical, orderly, or meaningful; (2) to devise plausible reasons to justify one's beliefs or acts, instead of giving the true motives which may be unconscious.

reaction time. The time between the giving of a stimulus and the subject's reaction to it.

receiving organs. The sense organs.

recondition. To replace an undesirable response to a given stimulus by a desirable response by the process of conditioning.

recovery curve. The curve indicating the improvement in the level of performance of a fatigued person as a result of successive increments of rest.

reflex arc. *See* neural arc.

refractory period or phase. A brief period of time following the excitation of a nerve, neural arc, or muscle during which it is incapable of transmitting impulses.

reinforcement. The action of one neural excitatory process upon a second so that it increases the latter's intensity or efficiency.

repolarization. Reestablishment of polarity in the nerve membrane following the passage of an impulse.

residual tensions. Tensions in muscles which persist after the occasion for their production has passed; tensions which remain when the rest of the musculature is relaxed.

resistance. The term has two meanings: (1) *See* galvanic skin resistance; (2) any obstacle which causes an organism to put forth extra effort.

respiratory calorimetry. The method of measuring the metabolic rate, or rate of energy production, by studying the ratio of the amount of oxygen taken in to the amount of carbon dioxide expired.

respiratory quotient. The ratio between oxygen taken in and carbon dioxide expired.

responding organs. The muscles, both skeletal and smooth; the glands, both duct and ductless.

satiation. The state of mind in which all interest in completing a task is gone. Similar in meaning to boredom.

satisfyingness. The degree to which work yields satisfaction to the worker.

self-competition. The urge or attempt to excel one's own past record.

sense perception. *See* perception.

sensory-neuromuscular. Involving all three components of the response arc; hence the complete chain of events from stimulation to response.

set. A temporary attitude or preparatory state of the organism which puts it in readiness and predisposes it to perform a particular kind of activity. Sets are partly maintained in terms of muscular tensions.

skeletal muscles. Muscles of arms, legs, trunk, etc., which move the parts of the skeleton.

skin resistance change. *See* galvanic skin resistance change.

sleep center. A region of the thalamus which lies directly below the cerebrum at the upper end of the brain stem.

spontaneous. Occurring without voluntary effort or preparation.

spread of inhibition. The theory that when a local inhibition develops in the central nervous system as a result of continuous or repeated stimulation, the inhibitory state tends to spread to neighboring regions.

standard score. A score expressed as a deviation of the individual from the average score of the group. It is given in units of the standard deviation of the distribution.

stimulus. Any physical change in the environment which excites a sense organ and usually initiates a response.

subjective. Relating to the individual's own conscious experience of which he alone has direct awareness.

submissiveness. The trait of being easily controlled by other persons. Opposite to dominance or ascendance.

subvocal speech. Thinking in terms of verbal processes which may or may not involve silent activity of the vocal mechanisms.

suggestibility. The trait or temporary set which causes a person to be responsive to suggestions.

suggestions. Social stimuli which are responded to uncritically by the person to whom they are directed, causing him to act in accordance with them.

susceptibility to monotony. Tendency to develop boredom and subjective and objective decrement when carrying on repetitive work.

syllogism. A formalized pattern for deductive reasoning consisting of (1) a major premise, (2) a minor premise, and (3) a conclusion drawn from 1 and 2.

synchronize. To cause two or more activities to occur together in time or in rhythm.

tenseness. A general state of tense musculature.

tension. The state of contraction of a muscle, whether voluntary or reflex.

thalamus. The part of the brain stem lying directly at the base of the cerebrum. Besides being the gateway to and from the cerebrum, it functions in emotional excitement, pain, and sleep.

therblig. The name for a constant part of a repeated work act, such as grasping, transporting, etc., devised by F. B. Gilbreth as an aid in recording and studying the worker's motions in the interest of economy of movement.

thymus gland. A ductless gland situated in the upper thorax which reaches its greatest size about the time of puberty and then slowly atrophies.

tonus or tonicity. A state of partial contraction of a muscle which is reflexly maintained, thus helping to maintain the postural attitudes of the body.

trait. A unit variable of personality which can be measured independently.

transfer of fatigue. Decrement in a given activity due to the transfer to it of the decrements developed in other related activities.

transfer of training or of learning. Improvement in an activity without practice in it, due to practice of some other related activity.

trial-and-error thinking. The method in which the correct responses are not foreseen but are hit upon more or less by chance in the process of trying out a number of possible solutions.

trough. The low point of efficiency in a wave or cycle of attention or performance.

variability. The tendency to vary in performance from moment to moment in either speed, accuracy, or quality.

verbal ability. One of the primary abilities; it enables a person to handle words and language symbols readily.

verbal thinking. Thinking in terms of language symbols or words rather than in terms of images.

vigilance. The alertness or readiness to react, or the degree of awakeness of the central nervous system maintained by the flow of incoming nerve impulses from sensory nerves.

vital organs. Stomach, heart, lungs, etc.

vital processes. Digestion, heart action, breathing, circulation, etc.

vocational interest test. A test designed to find out what vocation or group of vocations has the greatest appeal to a person.

warming-up. The improvement in the level of performance which sometimes occurs during the early part of the work curve; it results from becoming adjusted to the task and to the work setting.

wave of attention. *See* attention wave.

work curve. A graphic record of the amount of muscular or mental performance in successive time periods of uniform length.

work set. The set to perform a given task or kind of work in a given way. It is partly determined by the specific instructions which the worker has received from his superior.

TEST ITEMS FOR REVIEW

The following objective test questions are designed to give the reader an opportunity to check up on his grasp of the points covered in the text. He should first attempt to answer all the questions on a given chapter independently, and then refer to the chapter for verification or correction.

CHAPTER I

Question I. Decide whether each statement is true or false. Some of them are true; the others, false.

1. Nerves can respond to stimulations as rapidly as they are delivered, without any resting period between.
2. Among the organs which undergo wear and tear in mental work are the sense organs, brain and nerves, internal vital organs, and glands.
3. The brain waves which occur in concentrated thought are the large delta waves, while those which occur in sleep are those of smaller amplitude, known as the alpha waves.
4. Action currents occur in the fingers of deaf mutes when they are dreaming.
5. Since the nerve impulse is electrical, it travels at the speed of electricity.

Question II. Decide which is the best of the alternative words or phrases to complete the meaning of each sentence.

1. The increase in metabolism resulting from mental work is (1) very large, (2) insignificant, (3) small but significant, (4) large and significant.
2. Mental work is a process which (1) is confined to the brain, (2) involves the muscles as well, (3) is confined to the muscles, (4) does not occur in industry.
3. The nerve impulse is (1) electrochemical, (2) electrical, (3) chemical, (4) non-physical.

Question III. Decide what word to put in the blank space to complete the meaning of each sentence properly.

1. The chief mechanisms brought into play by a stenographer transcribing dictation on a typewriter are (1) receiving organs, (2) ...., and (3) responding organs.
2. The oxygen percentage in the air breathed into the lungs can be reduced to .... percent before mental reactions begin to show deterioration.
3. The effects of anoxemia appear first in the .... functions, and last in the reflexes.

Chapter II

Question I. True-false.

1. The brain maintains its own level of excitation without the necessity of the added excitation of incoming stimuli.
2. A certan minimum degree of tenseness in the body muscles is conducive to more efficient mental work.
3. It has been found that music played during working hours improves the level of output in repetitive work.
4. A worker's efficiency can be lowered by the presence of inhibitive emotional attitudes of which he himself is not aware.
5. An emotional inhibition which is originally aroused by some very particular experience has a tendency to spread to the whole personality and exert a depressing effect on all our activities.

Question II. Best answer.

1. All but one of the following are *internal* facilitators; which one is not? (1) muscular tonus, (2) music, (3) motives, (4) drugs like coffee.
2. Two of the following are factors which cause irrelevant stimuli to exert an inhibitive effect: (1) meaningfulness, (2) meaninglessness, (3) intensity, (4) constancy.
3. A work "set" is (1) a persistent or habitual directive attitude toward the task, (2) a name for the general setting under which the work is carried out, (3) neither of these.

Chapter III

Question I. True-false.

1. The interpolated task method of measuring fatigue assumes that fatigue is general, affecting all mental activities equally.
2. Fatigue can be defined as a diminished capacity for work as shown by a decrement in output.
3. Every worker has a "natural" rate of work, and any increase above this rate is accompanied by a decrease in the quality of the product.
4. Most persons are very good estimators of their capacity to do a given amount of work in a given time.
5. As a worker becomes fatigued mentally, his performance becomes (1) more variable, (2) less variable, (3) unchanged in variability, (4) stereotyped.

Question II. Best answer.

1. Mental fatigue can be measured in three of the following ways; underline the correct ones: (1) amount of output in successive periods of time, (2) number and character of brain waves, (3) changes in metabolic rate, (4) changes in feeling-tone or subjective tiredness, (5) strength of hand grip on a dynamometer.
2. One of the following is not a method of estimating the objective decrement in the work curve: (1) increase in errors from the first unit of work to the last, (2) level of output after rest minus the level at the end of the work period preceding rest, (3) time required per unit of work at the end of the work period, (4) average level of output in the first half of the work period minus average level in the last half.
3. Warming-up occurs in a work curve (1) when the worker knows that the end is near, (2) when there is a practice gain, (3) when the continuity of the task is not too great, (4) when the worker begins at a high level.

Question III. Fill in all the blank spaces.

1. In continuous repetitive work, there occur at frequent intervals ...., during which no response is made.

2. People who fatigue rapidly also show the greatest increase in number of ....
3. The main difference between Arai's and Painter's curves is in the rapidity of onset of the ....

CHAPTER IV

Question I. True-false.

1. The reason why we cannot work out "therbligs" for mental tasks is because we have no good way of determining the difficulty of a mental task.
2. A task which is difficult for a person of high intelligence would necessarily be difficult for a person of low intelligence.
3. The nature of the task is less important than the individual worker's attitude toward the task in determining the fatigue which will be developed in performing it.
4. A person will fatigue faster if he is told to add each one of a series of pairs of numbers than if he is told to add the first pair, substract the second, add the third, etc.
5. Tests have been devised for measuring a person's susceptibility to monotony.

Question II. Best answer.

1. All but two of the following are characteristics of fatiguing work; indicate which two are not: (1) meaninglessness, (2) familiarity, (3) conflict, (4) sameness, (5) discontinuity.
2. All but one of the following are indices of increased mental effort; indicate which is not: (1) increased muscular tension, (2) increased skin resistance, (3) increased oxygen consumption, (4) increased carbon dioxide expired.
3. The respiratory quotient means the ratio between (1) the amount of air breathed in and the amount of air breathed out, (2) the amount of oxygen breathed in and the amount of carbon dioxide breathed out, (3) the amount of carbon dioxide breathed out and the amount of air breathed out, (4) none of them.

Question III. Fill in all the blank spaces.

1. The rate at which the organism generates and uses energy is known as the .... rate.
2. When mental work is accompanied by severe emotional strain, the blood and urine sometimes show an increase in .... content.
3. Tension in the body muscles tends to .... as the work period goes on.
4. Rest and relaxation cause a .... in skin resistance.

Chapter V

Question I. True-false.

1. The subjective feelings accompanying mental fatigue are like those accompanying fatigue from physical work.
2. Those tasks which show the largest decrements in output also show the greatest drop in feeling-tone.
3. It is attitude which finally breaks down in mental work.
4. Variations in initial feeling-tone level from day to day are as great as those between the beginning and end of work on a given day.
5. Feeling-tone changes and organic state are closely correlated.

Question II. Best answer.

1. Feeling-tone in mental work and physical work deteriorates (1) faster than output, (2) less rapidly than output, (3) at about the same rate as output.
2. The most satisfactory number of degrees to use in a feeling-tone scale is (1) three, (2) five to seven, (3) ten or more, (4) none of these.
3. Neurasthenia, a type of mental fatigue, is best treated by (1) some physical and mental activity, (2) complete relaxation and rest in bed, (3) keeping the mind a blank.

Chapter VI

Question I. True-false.

1. Fatigue is specific to the sensory-neuromuscular elements used

in a task and does not transfer to other tasks which are engaged in subsequently.

2. If the general controlling set, the work set, becomes fatigued, this decrement will transfer to all tasks involving such a controlling set.
3. Chapman found that alternating between adding figures and canceling letters brought 50 per cent as much relief as alternating between work and rest.
4. Mild amounts of physical fatigue are without any marked effects on subsequent mental activity.
5. A change in the setting or surroundings in which work is going on may give as much relief from fatigue as a change of task.

Question II. Best answer.

1. The greatest amount of fatigue transfer occurs between (1) a mental and a physical task, (2) two dissimilar mental tasks, (3) two similar mental tasks, (4) two mental tasks which use a common reservoir of energy.
2. Three of the following are true principles of fatigue transfer, but one is false; indicate which is false. Fatigue transfer occurs when (1) the two tasks are carried on in different work settings, (2) the first task is so complex that it fatigues a wide range of mechanisms, (3) the tasks are very much alike, (4) both tasks are physical and involve the same musculature.

Question III. Fill in all the blank spaces.

1. The tendency for the brain and nervous system to work together as a whole or unit in every reaction is called the principle of ....
2. In the case of her subjects who worked two hours on mental multiplication, Arai found that .... per cent of the decrement transferred to the subsequent task of learning syllables.
3. Fatigue resulting from the job of supervising a whole department would be .... fatigue, whereas the fatigue resulting from adding columns of figures all day long would be .... fatigue.

Chapter VII

Question I. True-false.

1. Long rests between work periods are not advisable because they abolish the work set and leave the worker unready to resume work.
2. How the rest period should be spent depends on the job, but complete physical relaxation is not always best.
3. The frequency of rests should be directly proportional to their length.
4. The recuperative value of a change of task is felt mainly at first, right after the change is made.
5. Curves of recovery show a rapid rise during the first few minutes of rest, and a reversal later on.

Question II. Best answer.

1. The most beneficial length for a rest period introduced during mental work after the first hour is (1) as long as possible, (2) at least twenty minutes, (3) about five minutes, (4) more than five but less than fifteen.
2. Rests are best introduced at the point in the work curve where (1) the decrement begins, (2) the decrement ends, (3) the initial spurt ends, (4) the end spurt begins.
3. Which one of the following conditions does *not* require a lengthened rest period after a given length of work period: (1) work done under a strong incentive, (2) work involving sameness, (3) novel tasks, (4) varied tasks.

Chapter VIII

Question I. True-false.

1. The fact that a number of famous men have got along on very little sleep shows that most of us sleep too much.
2. The regular diurnal recurrence of sleep in most people is dependent on being fatigued and on the presence of fatigue toxins in the blood.

3. The effects of loss of one night's sleep are felt less the day immediately following than later.
4. Most persons require between seven and nine hours in bed, of which from six to eight are spent in actually sleeping.

Question II. Best answer.

1. Three of the following explanations of why we sleep are acceptable; indicate which ones are: (1) fatigue poisons, (2) brain anemia, (3) instinct, (4) brain center, (5) lowered vigilance of the brain, (6) ameboid movements of nerve endings, (7) a learned habit.
2. One of the following is not an accepted method of measuring the depth of sleep at any given time: (1) skin resistance changes, (2) strength of sensory stimuli required to awaken the sleeper, (3) number and extent of the sleeper's movements.
3. Two nights' loss of sleep will cause (1) profound changes in the brain tissue, (2) dazed feelings, hallucinations and lessened emotional control, (3) great decrease of mental efficiency on tests, (4) very marked physiological effects.

Question III. Fill in all the blank spaces.

1. The process by which a number of stimuli acquire the capacity to call forth the response of sleep as a result of past experience is called ....
2. The theory that sleep or unconsciousness results from the removal of the reinforcing effect of incoming stimuli from muscles, etc., to the brain is called the .... theory.

Chapter IX

Question I. True-false.

1. The usual statement that a person can attend to only one thing at a time is not true.
2. A person can attend to a lecture or radio talk continuously for at least a half hour with no lapse of attention.
3. Attention involves the processes of both facilitation and inhibition in the central nervous system.
4. Internal factors of habitual work set, interests, needs, etc., are

more important determiners of what we shall attend to, as a rule, than the external factors of intensity, change, or duration of the stimuli.

Question II. Best answer.

1. Three of the following factors increase the distracting power of irrelevant stimuli; underline all three correct ones: (1) novelty, (2) change, (3) uninterestingness, (4) intensity, (5) range.
2. Irrelevant stimuli introduced into a work situation will have a facilitative or neutral effect if (1) the work task is not well practiced, (2) the irrelevant stimuli are habitually present, (3) the worker is aroused to greater effort to overcome them.
3. We can learn to control attention by all but one of the following helping rules; which one is wrong? (1) making an ally of habit, (2) freeing the mind of conflicts, (3) disregarding physiological conditions, (4) being sure our interest in the task to be done is aroused.

Question III. Fill in all the blank spaces.

1. The kind of attention given to things that interest us, with no effort, is ....
2. The kind of attention that results from habit formation through past effort is ....
3. The kind of attention that requires real conscious directive effort on our part at the time is ....

Chapter X

Question I. True-false.

1. There must be a motive present in a worker to which a given incentive can appeal, before the incentive will become effective.
2. The sustaining motives are mainly social; the energizing motives are mainly biological.
3. If we can show that current output is increased by introducing a given incentive into the work situation, we have proved its value.
4. For adequate self-motivation, long-time goals must be rein-

forced by setting up nearby goals of a more or less artificial character.

5. The problem of overcoming the initial inertia in ourselves toward beginning a new task is best met by bringing external pressures to our aid.

Question II. Best alternative. In each of the following pairs of incentives one is more effective than the other. Indicate which is better in each case:

A single incentive	A combination of incentives
Praise	Reproof
Penalties	Rewards
Group incentives	Individual incentives
Opportunity for advancement	Size of wages
Discouragement	Encouragement
Self-competition	Competition with others
Competition	Cooperation

Chapter XI

Question I. True-false.

1. As compared with the energy used up in actual mental work, the amount that is consumed in emotional reactions is far greater.
2. Emotions are specific, applying only to the stimulus or situation which originally excites them.
3. More cases of chronic disturbance are likely to occur in persons who try to suppress their emotions than in those who allow them free rein.
4. In general, the impersonal sources of emotional strain, noises, etc., are more serious than the personal ones, such as inconsiderateness in the behavior of associates.
5. The best way to avoid continual worry is to learn to come to a decision and abide by it.

Question II. Best answer.

1. Of the following ways of dealing with subordinates under one's direction, underline the best one in each pair across the page.

Always specify definitely the nature and amount of the thing to be done.	Do not tell the subordinate how much is to be done for fear of discouraging him.
Be sure the worker has enough opportunity to receive preliminary drill in the task to do it well.	Assume that the worker should already have acquired the skill or should use common sense.
Insist on the worker keeping his attention directed to the ultimate goal.	Specify immediate objectives that can be attained quickly so as not to delay favorable comment.
Keep the worker in the dark as to how he is doing, so as to keep him guessing.	Let the worker know objectively whether he is succeeding or not.

2. Of the following pairs of methods of dealing with annoying social situations, underline the superior one in each case:

Bury all emotion under the surface.	Seek to discover and remove the source of friction.
Express your opinions in a somewhat disguised form.	Try to avoid persons with whom you have friction.
Do nothing directly, but retaliate in subtle and indirect ways.	Handle the person in the way that would be most likely to get results if you were he.
Establish a cooperative attitude in the other person.	Have it out with the person.

Chapter XII

Question I. True-false.

1. The effect of such social suggestions as the war slogan "Remember Pearl Harbor" is probably very slight in increasing industrial efficiency.
2. If a worker approaches a difficult task with the impression

that it is easier than it really is, he will accomplish more than if he knows how hard it is.

3. If we frequently belittle our own worth, other people are more likely to take us at our word than to consider us modest.
4. As a rule, autosuggestions are less effective than suggestions coming from other persons whose prestige value is high.
5. An expression of group opinion is less effective in changing the ideas of a member of the group than is the expressed opinion of an expert.

Question II. Best answer.

1. The effect of working in the presence of other social beings is: (1) greater if they are co-workers, (2) more beneficial to quality than to speed, (3) always positive, (4) always negative.
2. Three of the following factors aid the effectiveness of suggestions; the fourth does not. Indicate which it is: (1) prestige, (2) intelligence, (3) absence of opposing ideas, (4) appeal to emotional prejudices.

Question III. Fill in all the blank spaces.

1. Action which follows upon the presence of an idea of it, without necessarily involving deliberation or conscious intention on the actor's part, is called .... action.
2. Suggestions which do not involve a direct presentation of the idea to be conveyed are known as .... suggestions.
3. Persons who respond in the reverse manner to that implied in the suggestions given them are said to be .... suggestible.

Chapter XIII

Question I. True-false.

1. Within limits, there is a steady increase in efficiency in jobs requiring close eyework as illumination is increased.
2. Colored illumination is usually more effective than plain white light.
3. If more work is accomplished in noisy surroundings it is at the expense of a more than compensatory increase in energy expenditure.

4. There are no fundamental unchangeable physiological rhythms which set the course of diurnal efficiency.
5. The most efficient season for work, both mental and physical, has been shown to be winter.

Question II. Best answer.

1. Diurnal variations in efficiency depend most on (1) habit, (2) physiological factors, (3) instinct, (4) none of these.
2. Muscle tonus is highest (1) the first thing in the morning, (2) at noon, (3) later in the day.
3. Of the following conditions of weather and ventilation, which two have the most influence on mental efficiency under ordinary conditions of work: (1) barometric pressure, (2) temperature, (3) circulation of air, (4) oxygen content of room, (5) carbon dioxide in air of room.
4. Of the following drugs, which are stimulants: (1) alcohol, (2) benzedrin sulfate, (3) tobacco, (4) caffeine.

Chapter XIV

Question I. True-false.

1. Learning to perform an act well which we have previously performed in a mediocre manner is largely a matter of adopting a changed attitude toward doing it, with a conscious intention to improve.
2. Becoming an expert is as much a matter of knowing what not to learn as of making an effort in learning.
3. If we repeat an act often enough we will surely improve in it.
4. Spaced effort in learning is superior to massed effort.
5. The occurrence of a plateau in the learning curve is an indication that the learner can expect to make no further progress.
6. It is not true that it is always best to stress accuracy first and speed later in learning a skilled performance.
7. To break an undesirable habit, one should give attention to the incorrect habit, not the correct one.
8. The performance of the incorrect habit should be accompanied by as much unpleasantness as possible.

9. Forgetting is caused by the passive fading-out of impressions or habits with the passage of time.
10. If the activities engaged in between the learning and recall of a habit are very similar to the habit we are trying to retain, the disruptive effect is more severe than when they are quite different.

Chapter XV

Question I. True-false.

1. Mental diseases show a sharply rising curve after the fifty-fifth year.
2. Sheer physical strength and muscular agility are at their peak before twenty years of age.
3. Because of the poor vision and muscular unsteadiness of persons past fifty, the accident rate at that age exceeds the rate for people around twenty.
4. As a result of the decline in mental alertness which sets in around thirty-five years of age, judgment is considerably impaired from that time on.
5. Since a man past fifty is ready for the shelf, he would gain nothing from a careful reappraisal of his abilities.

Question II. Best answer.

1. Of the following mental functions, the two which undergo the greatest loss with age after thirty-five years are: (1) range of information, (2) ability to learn new material, (3) ability to recall old material, (4) judgment, (5) general intelligence or alertness.
2. The age of greatest intellectual productivity in most lines is (1) 20 to 29, (2) 30 to 39, (3) 40 to 50.
3. The age when leadership reaches its peak in politics and business is (1) before 35, (2) 35 to 50, (3) past 50.

Question III. Fill in all the blank spaces.

1. Four good ways to counteract the effects of growing old on intellectual alertness are: (1) ...., (2) ...., (3) ...., (4) ....

Chapter XVI

Question I. True-false.

1. General intelligence is a unitary thing and cannot be further subdivided.
2. If a person is intelligent in one direction he is almost sure to be intelligent in all other directions, and vice versa.
3. The differences in intelligence which show themselves early in the life of children tend to persist throughout life.

Question II. Best answer.

1. The intelligence quotient is a measure of mental alertness obtained by finding: (1) the mental age divided by the chronological age, (2) the chronological age divided by the mental age, (3) the mental age multiplied by the chronological age, (4) the percentile rank divided by the standard score.
2. To make a good secretary who could compose a letter now and then for the boss while he is away, a girl would have to have an I. Q. of at least (1) 85, (2) 95, (3) 105, (4) 115.
3. The Bernreuter test is used to test (1) mechanical aptitude, (2) interests, (3) personality traits, (4) intelligence.
4. Of the following dimensions of personality, the most easily changed is (1) general aptitude, (2) specific aptitudes, (3) personality traits, (4) interests.

Question III. Fill in all the blank spaces.

1. The four dimensions of human nature which should be measured befort a person decides on his vocation are (1) ...., (2) ...., (3) ...., (4) ....
2. A graph designed to show a given person's standing in relation to other persons in a number of different traits simultaneously is called a ....

Chapter XVII

Question I. True-false.

1. The secret of effective organization is the achieving of a higher degree of unity.

2. The proper position for a work desk is so that the person seated at it receives the light in his face.
3. A person should not allow himself to develop position habits with reference to the location of tools and articles in his work room.
4. If you want a thing done well, always do it yourself.
5. It is only by consciously organizing life with reference to clear-cut goals that the fullest satisfaction can be gained.
6. Hobbies should be avoided because they detract from the oneness of mind which a man should devote to his job.
7. An important component of personal morale is the identification of oneself with something outside oneself which is bigger than oneself.

Question II. Fill in all the blank spaces.

1. The major resources which a person has at his disposal in planning his work life are: (1) ...., (2) ...., (3) ...., (4) ....
2. The essential components of an adequate life plan that takes in the whole life are: (1) friends, (2) ...., (3) ...., (4).............., (5) ....

Chapter XVIII

Question I. True-false.

1. The term "thinking" refers to the solving of theoretical problems, and does not apply to such trial-and-error solutions as are involved in getting your car started after it has stalled.
2. Information is rarely precise or accurate unless it has been reduced to words or quantitative symbols and remembered in that form, rather than in the form of images.
3. New knowledge must be fitted into a framework before it is in shape to use.
4. If two sets of facts are found to be correlated, this is sufficient evidence that they are causally related.
5. If a belief has never been proved to be false, this is sufficient evidence that it is true.
6. Arguments from analogy are valid only provided the items

compared have points of resemblance which are real, basic, and numerous, and no point of crucial difference.

7. A false premise leads to a false conclusion even if the logical process of the syllogism is correct.

Question II. Fill in all the blank spaces.

1. That form of thinking which consists in finding justification for beliefs which we have already adopted rather than the discovery of new truth is called ....
2. In the symbolic syllogism below, identify the terms asked for by putting the proper item from the syllogism in each of the blanks provided for that purpose.

	All X is Y.	(a) the minor premise ....
	Z is X.	(b) the major premise ....
Therefore	Z is Y.	(c) the middle term ....
		(d) the major term ....

3. The *statement that "capital punishment is wrong because it* is wrong to take human life" involves the fallacy of ....

   ....

4. All men are either fascists or communists. This statement illustrates the fallacy of ....

Question III. Best answer.

1. One of the following processes is *not* involved in the acquiring of adequate information: (1) observing, (2) selecting, (3) deducing, (4) organizing and relating.
2. One of the following steps in trial-and-error thinking is out of order, being placed ahead of its proper position; which is it: (1) the existence of a problem, (2) suggestions as to its possible solution, (3) generalizing, (4) trying out several possibilities, (5) verifying the hypothesis.

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